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Materials in Design Engineering

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This periodical is indexed regularly in the Engineering Index and the Industrial Arts Index

Materials
in Design Engineering. *formerly Materials & Methods*

Selection & use of metals, nonmetallics, forms, finishes

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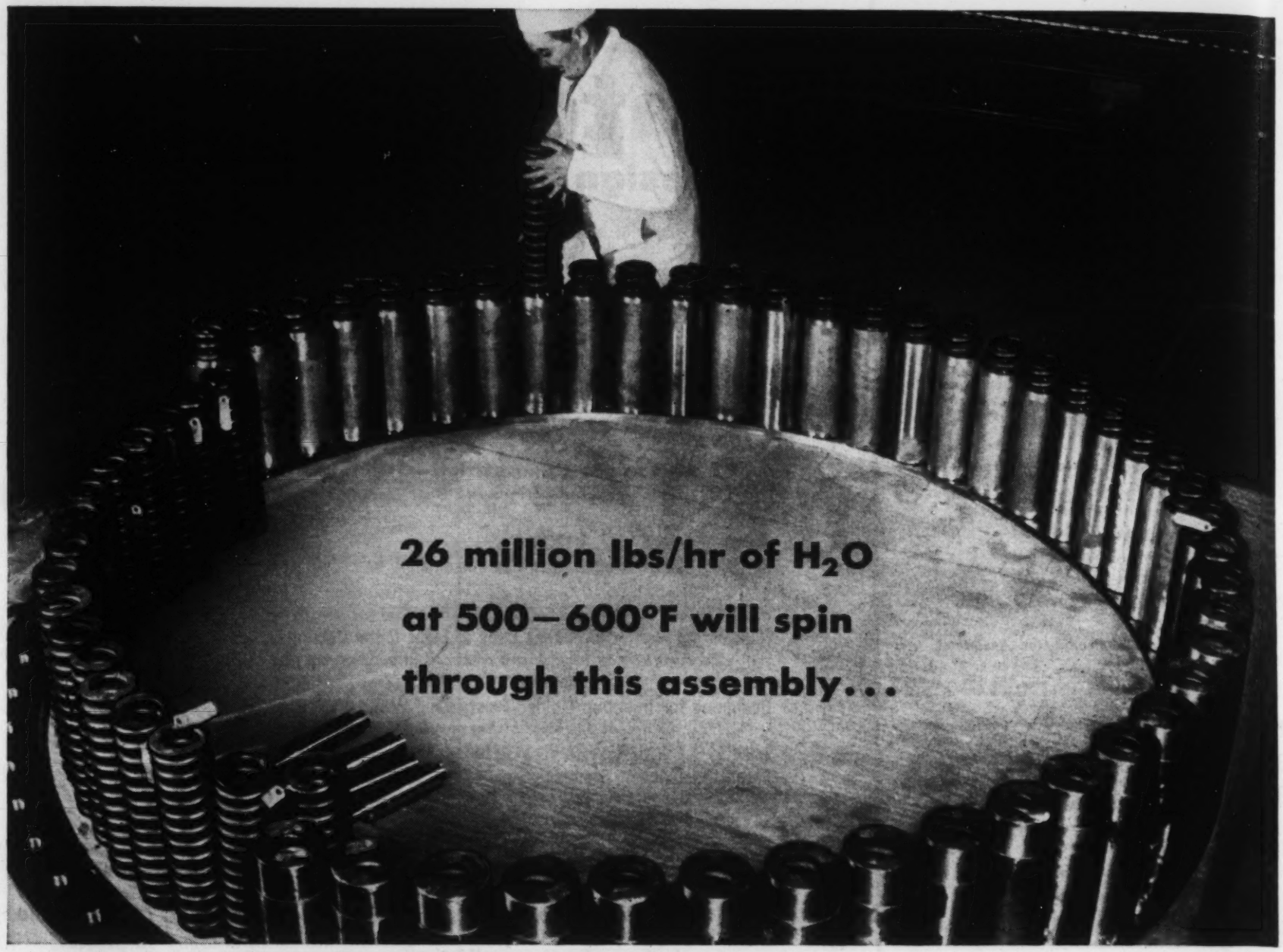
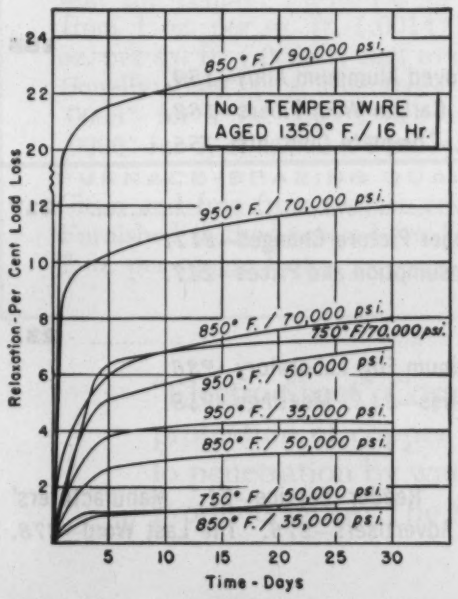


Photo courtesy of Combustion Engineering Inc.

How Inconel "X" is used in Shippingport reactor to make sure core mount springs stand up

Superheated high-purity water makes many ordinary spring materials relax quickly. It may cause them to fail by stress-corrosion cracking or embrittlement.



Relaxation of Inconel "X" springs made from No. 1 temper wire.

An outstanding exception is Inconel "X"* age-hardenable nickel-chromium alloy. Springs of this alloy resist both corrosion and heat . . . up to 1100°F in certain applications.

Here are some relaxation curves, for example, which show what stresses Inconel "X" alloy is capable of handling at various temperature levels.

The curves speak for Inconel "X" alloy. When you want springs that resist relaxation at high temperatures this is the alloy to use . . . just as Combustion Engineering Inc. has done in spring mounting the core of this reactor, for a plant designed by Westinghouse Electric Corp. for operation by Duquesne Light Co.

Inconel "X" gives you valuable bonus properties too

Inconel "X" alloy also offers you (1) excellent corrosion resistance (2) outstanding hardness and wear resistance (3) high fatigue strength (4) high tensile strength (5) low thermal expansion (6) resistance to stress-corrosion cracking.

Other Inco Nickel Alloys . . . more than fifty . . . offer designers other equally useful properties. Take Inconel 713-C*, for example, a new nickel-chromium cast alloy for 1700°F service. Or Duranickel* age-hardenable nickel with high strength and hardness. Properties of many of these alloys are summarized in the Inco booklet "Standard Alloys for Special Purposes." May we send you a copy?

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What's new IN MATERIALS

...AT A GLANCE

STRESS CORROSION CRACKING OF STAINLESS STEEL may be explained by the formation of crystals on the surface of stainless steel parts that are exposed to corroding atmospheres. Scientists think this growth causes a chemical cutting of the metal, forming minute crevices as the crystals grow. The crystal growth may lead to concentration of stress at the base of the crevices and eventually to failure of the metal. (More details next month.)

A SILICONE-EPOXY COATING, said to provide protection against acids, alkalis, oils, solvents and moisture, is now commercially available. It contains no plasticizers or oils and cures by both solvent evaporation and internal polymerization. It is recommended as a coating for tanks, boats, machinery and traffic lanes.

PERMANENT MAGNETS AS SMALL AS A HUMAN HAIR have been made in the laboratory from an alloy of 60 copper, 20 nickel and 20% iron. The tiny magnets are made by cold drawing the alloy through diamond dies to form a wire having a diameter of 0.005 in. After cold drawing the wire is heat treated at a temperature slightly above 1100 F.

SILICONE LUBRICANTS THAT CAN OPERATE AT 700 F are available for use in lubrication systems of aircraft, missiles, refrigerators, compressors, clocks and timing devices. The lubricants are said to have good lubricity, oxidative stability and thermal stability. They have a viscosity of 40 to 70 centistokes at 100 F, a pour point below -100 F, and a fire point of over 600 F. They sell for about $5 per lb in drum lot quantities. (More details next month.)

STRONG STAINLESS STEEL AIRCRAFT STRUCTURES, said to be 25% lighter in weight than structures made of aluminum, titanium or steel, can be produced by welding miniature corrugated sheets to very thin stainless steel skins. According to the producer, the corrugated sheet-skin combination, rigid in one direction only, uses the full strength of the materials involved. This type of construction can be used for tailpipes, firewalls, panels, fuel tanks and other structural and nonstructural aircraft parts.

A NEW HIGH DENSITY POLYETHYLENE YARN is said to be particularly useful for outdoor applications. Fadeometer tests reveal that some colors of the yarn withstand as many as 800 to 1500 fadeometer hours

with no sign of change. The yarn is recommended for outdoor furniture webbing, upholstery and automobile seat covers.

EXPLOSIVE FORMING OF TOUGH METALS may someday be used in volume production of aircraft parts, recent research suggests. Basically, explosive forming releases energy at such a high rate that the metal is punched or formed "before it knows what happens." Current experiments indicate that cartridge actuated devices may be used to punch holes in high strength alloys, to flare and bulge tubing, and to form "nonformable" alloys of stainless steel.

WATER SOLUBLE POLYETHYLENE OXIDE RESINS with extremely high molecular weight are currently available in limited quantities. According to the producer, the resins can be cast, calendered and extruded into tough, flexible films for packaging and other applications. They have a yield strength of 1300 to 1500 psi, an elongation of 1100 to 2000% and a tensile strength of 1800 to 2400 psi; key property seems to be extremely good plastic memory. (More details next month.)

NEW DEVELOPMENTS IN PAINT: 1) An organic, nontoxic paint additive is said to make paint films resistant to mildew, infectious fungi and bacteria. According to the producer, the additive is effective in most paint formulations, lasts for the life of the paint and requires no special precautions in handling. 2) An alkyd emulsion is said to make possible water thinned gloss paints with properties approximating those of solvent thinned gloss paints.

A FLAME SPRAYED NICKEL-MAGNESIA CERMET COATING, is said to withstand temperatures in excess of 2000 F without any apparent effect on the coating. The coating is also said to have good thermal shock resistance and insulating properties. Current tests show the cermet coating is not resistant to all atmospheres at high temperatures.

A NEW HIGH STRENGTH STEEL ALLOY is now commercially available. The alloy, a combination of manganese, molybdenum, copper and boron alloyed with steel, is recommended for use in earth moving, mining, agricultural and conveyor equipment. It is available in hot rolled plates and bars.

BETTER LEATHER AT LESS COST may result from new animal hide treating processes that use organic solvents instead of caustic soda and sulfuric acid; at least three of these processes are now being evaluated. Initial investment costs for solvent processing equipment are said to be offset by increased leather yield, decreased processing time and lowered processing costs.

Turn to page 155 for more "What's New in Materials"

MATERIALS BRIEFS

No Place Like Foam

Traditional igloos of snow may be a thing of the past if an experimental plastics igloo now being evaluated in Arctic regions proves feasible. The palstics igloo, made of polystyrene foam blocks, withstands most temperature extremes and can be assembled in about two days.

Foundry in the Basement

You can now make 1½ to 6-lb metal castings right in your own basement with a new "do-it-yourself" casting kit. The kit, selling for less than $50, contains a furnace, a blower and crucibles.

No More Darkroom

Photographic negatives can be developed from a new vinyl plastics film without the use of a darkroom, chemicals or water. The film is developed by exposing it to ultraviolet rays for 20 sec, then baking it in an oven at 350 F for 2½ min.

Magnetic Monster

A permanent magnet, weighing 1300 lb and capable of holding 10 tons, is claimed to be the largest magnet ever made. Used in a mass spectrometer, the magnet is made of an aluminum-nickel-cobalt-iron alloy.

Sounds Fishy

A watertight "fish caller," housed in a two-compartment butyrate plastics case, is said to attract fish by sounds coming from an underwater buzzer. The device, consisting of a buzzer unit and a flashlight battery, operates without the use of wires or other outside devices.

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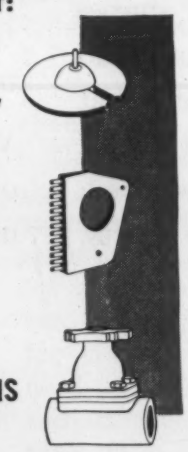
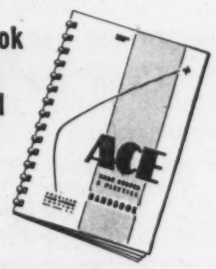


COME to think of it, we're a little amazed ourselves at the way Ace engineers can blend the mechanical, electrical and chemical properties of different rubber and plastic materials. Their aim is always to find the one best material for each of your jobs . . . never *over*designed . . . with production economy a must. Result: hundreds of tailor-made rubber, plastic, and rubber-plastic alloys to choose from . . . plus many unusual materials like Ace-Tex pyrobitumens. Ask us for anything from rough-ground rods to finished molded assemblies. Our facilities for molding, extruding, fabricating, and lining are among the world's largest.

Always check your ACE design engineer's Handbook when selecting materials for today's production and tomorrow's plans. If you haven't a copy, write today! It's Free.



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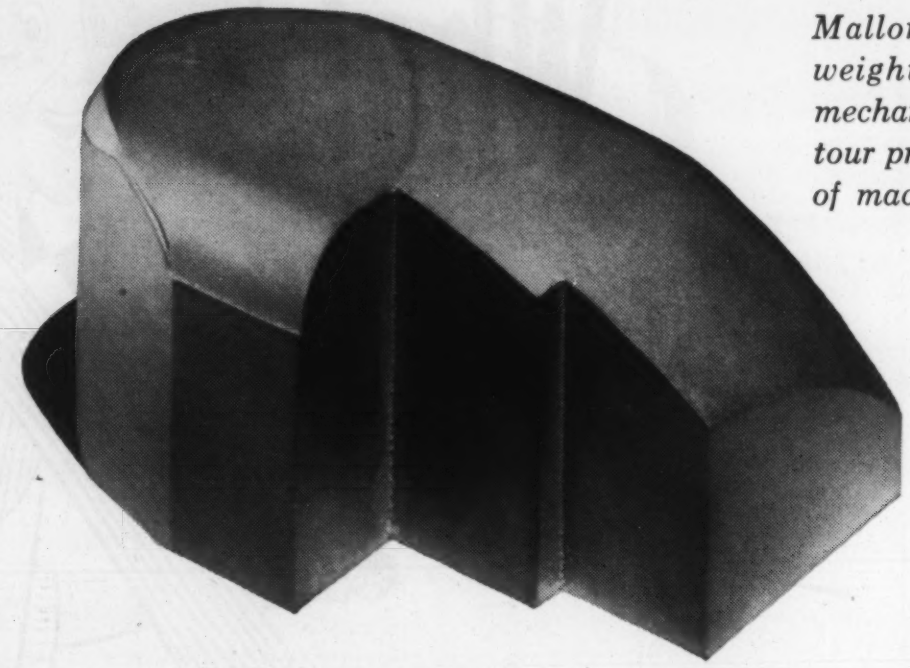

Mallory 1000 Metal counterweight, for an aircraft control mechanism, is produced by contour pressing at one-third the cost of machining from a solid blank.

Mallory Contour Pressing Cuts Costs of High Density Metal Components

COMPLEX SHAPES of high density Mallory 1000 Metal, for use in counterbalances, counterweights and similar mass components can often be manufactured *without any* rough or finish machining.

The exclusive Mallory contour pressing technique permits forming, in a single, economical operation, a wide range of complex shapes from Mallory 1000 Metal. Dimensions and surface finish are held to close tolerances that are ample for many types of products, with no subsequent machining being required. Even for extremely close tolerance parts, contour pressing sharply reduces the amount and the cost of final grinding or cutting.

The unique combination of strength, density and uniformity offered by Mallory 1000 makes it industry's top choice for weight elements in aircraft controls, gyroscope rotors and similar devices. Strict quality control during manufacturing assures rigid adherence to specifications, in each piece and throughout every lot.

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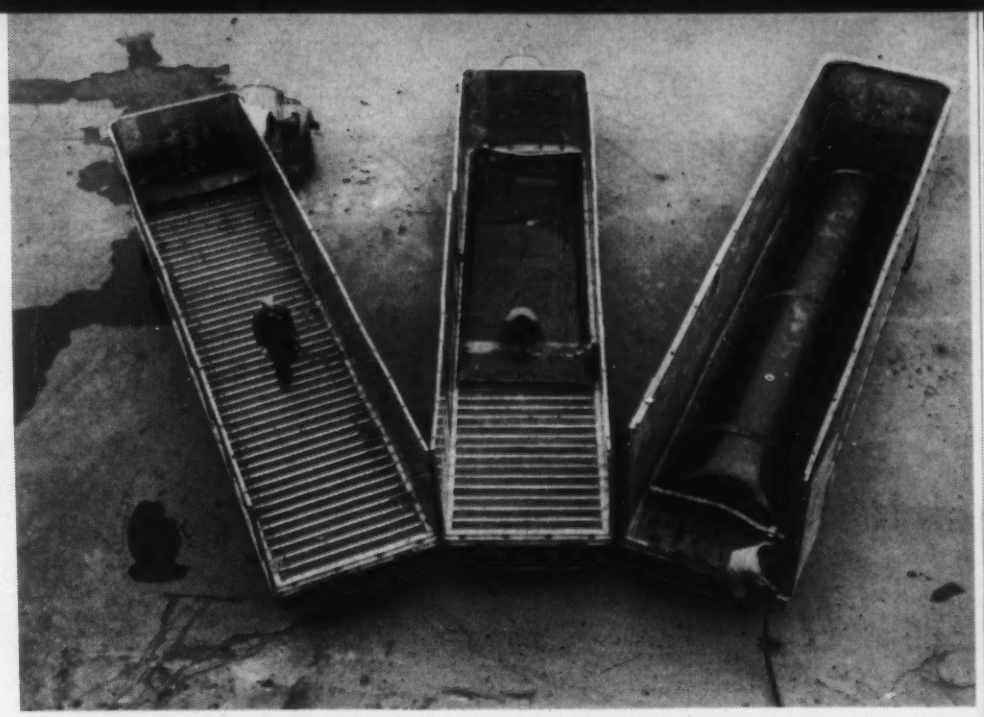
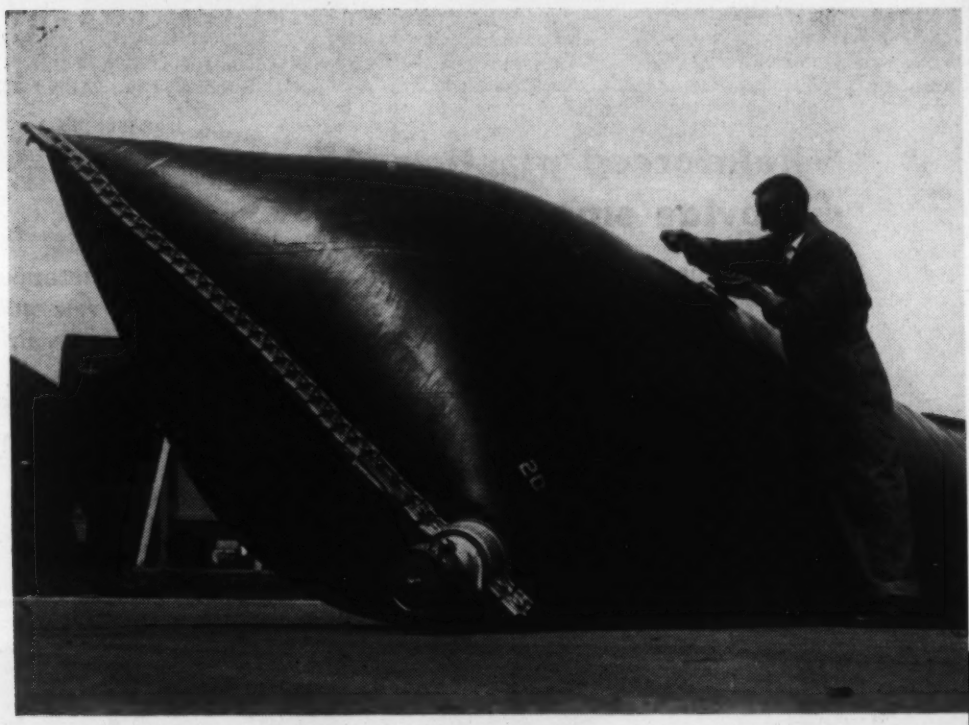
MATERIALS AT WORK

New and interesting applications of engineering materials





Rubber tube is unrolled *and filled with liquid after dry cargo is unloaded.*

Inflatable rubber tube solves dry-liquid transportation problem

The overgrown "toothpaste tube" shown above is 56 in. in dia and 35 ft long, and has a 3800-gal capacity. When filled, it weighs 22 tons; when empty it lies flat and can be rolled into a compact cylindrical package 25 in. in dia and 7 ft, 4 in. long. It is made of rubber and is used for transporting any type of liquid, including highly corrosive chemicals.

Called the Sealdtank and developed by U. S. Rubber Co., the giant tube is composed of four plies of rubber-coated rayon tire fabric molded similar to a tire. Both ends are sealed with metal enclosures resembling spinal columns. Its outer surface is made of neoprene. The inner surface can be made of any of a variety of rubber compounds, but for transportation of edible liquids a polyethylene bag is used as a liner. The tube is filled through a fitting at one end or from the top. Atmospheric pressure collapses the tank as it is emptied.

The Sealdtank is available in several sizes to fit any truck, trailor, railroad car, barge or ship. Main advantage in its use is that it allows one vehicle to transport both dry and liquid cargoes.

Barrett Div., Allied Chemical & Dye Corp.

Reinforced plastics skis provide smooth landing

High impact strength, light weight, weather resistance and elimination of freeze-down and sticking are the reasons given for the selection of glass-reinforced polyester resin for the aircraft skis shown in the accompanying photo.

The skis, manufactured by Airglas Engineering Co., are available in four different sizes and are easily attached to the plane. They require little maintenance and are said to be especially useful in deep snows.

Complex magnesium casting used for air scoop

What appears in the photo above to be a growling monster from somewhere beyond Sputnik is actually a magnesium casting which is playing an important role in Chance Vought Aircraft's attempt to conquer space.

The 150-lb magnesium casting, the most complex ever used by Vought and believed to be the most complicated close tolerance, thin wall magnesium casting yet produced, is used as an air scoop on supersonic jet aircraft. The air scoop not only supplies necessary engine air but includes ducts to bleed off a portion of the boundary layer air into openings under the wings. The remaining portion of boundary air is used for the oil cooler.

The casting mold for the air scoop stands 6 ft high and requires 10 tons of sand. Nominal thickness on walls and webs is 0.24 in. and the solid leading edge tapers to a 0.015-in. cast radius. Casting tolerance is 0.03 in. on dimensions up to 12 in., with an additional 0.002 in. per in. on dimensions above that.

Armco Steel Corp.

Stainless makes best fastener for jet plane

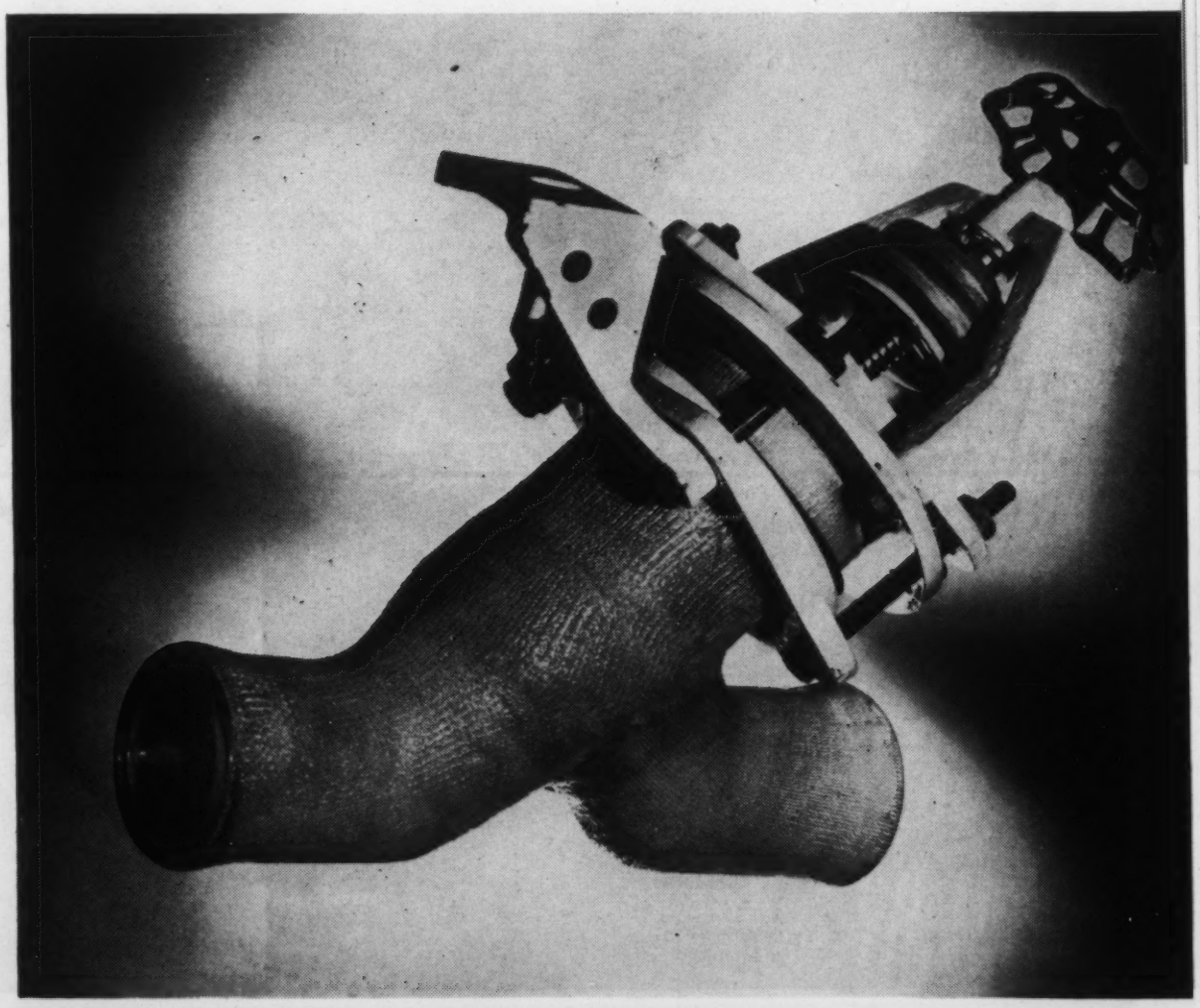
The switch from a nonferrous metal (left) to 17-4PH stainless steel (right) for body parts of a fastener used on jet planes has resulted in thinner sections capable of withstanding much higher temperatures ranging as high as 900 F.

The aluminum fastener, previously used on propeller-driven planes, could not withstand the higher temperatures generated in jet planes. Various metals were considered, but according to the manufacturer only the precipitation hardening stainless steel was found to satisfy all the requirements of strength, heat and corrosion resistance and ease of fabrication.

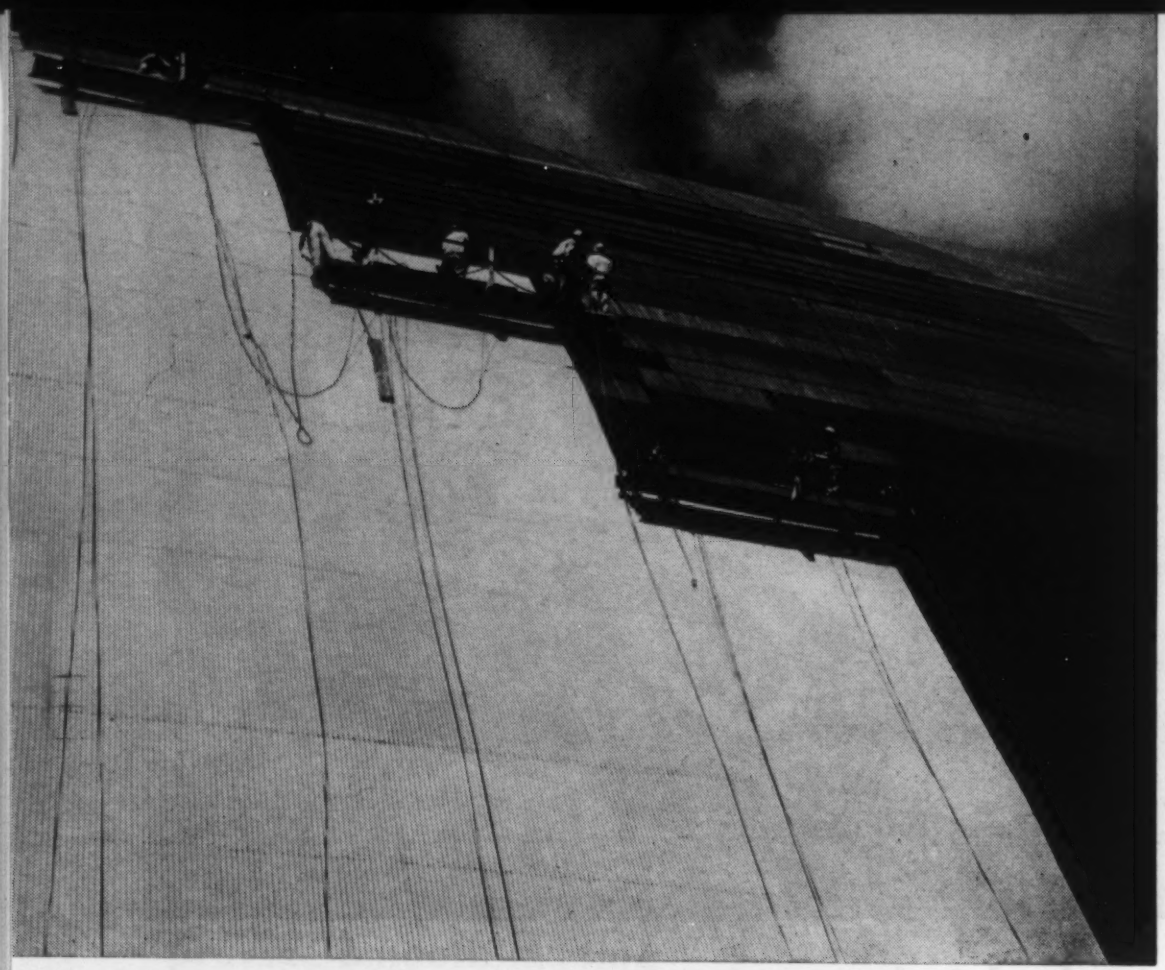
All-glass valve is tough, lightweight

A new Y-type valve made completely of glass is said to be corrosion resistant, tough, lightweight and compact. Manufactured by Corning Glass Works, the valve is recommended for use in processing all acidic metallic salts, various crystalline slurries, and all acids except hydrofluoric and concentrated phosphoric.

The 2-in. valve is made of tempered borosilicate glass and is reinforced with an armor of fibrous glass-polyester resin. Low thermal expansion of the glass allows sudden temperature differentials of 200 F. Maximum line pressure is 50 psi. The valve is less than a foot high, only 10 in. wide and weighs 9 lb.



MATERIALS AT WORK



To cover massive roof *with corrugated aluminum sheet . . .*

Hangar Sheath of Aluminum

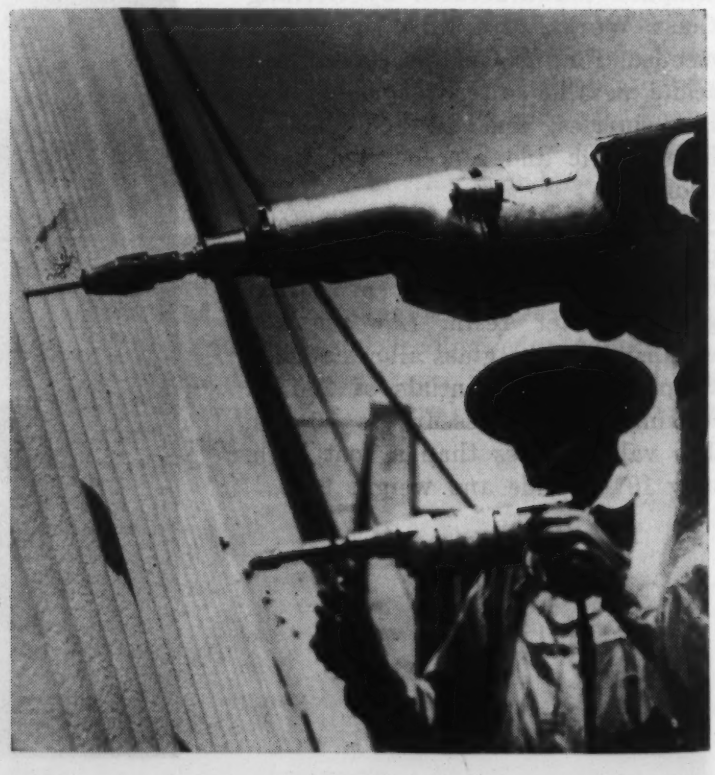
Costly maintenance problems on two of the Navy's blimp hangars are being eliminated by the installation of more than 600,000 lb of corrugated 3004 aluminum alloy sheet. The sheets are being used to protect a roof area of approximately 9½ acres.

Previously, the hangars were roofed with wood sheathing and built-up composition roofing paper. Leaks and other damage required constant repair and patching. According to the Navy, the corrugated aluminum roofing has three main advantages: 1) it requires the lowest expenditure for maintenance; 2) it is the most inexpensive, durable, permanent type roof available; and 3) because of its light weight, it can be installed without changes in the structure.

(continued on p 200)

. . . individual sheets *are placed in position and . . .*

. . . fastened *with self-tapping screws.*



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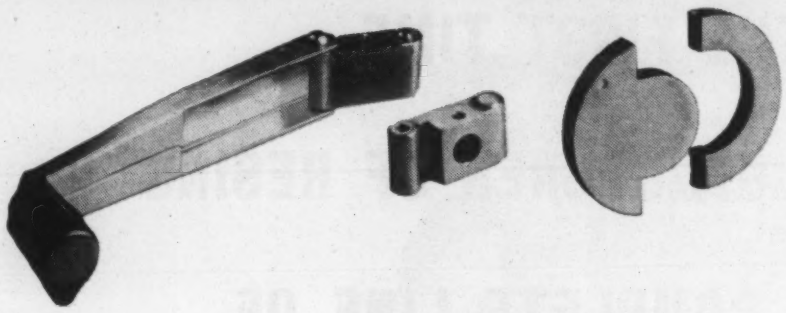
MEETING DESIGN NEEDS



The camera crank hinge, door knob and key for this REVERE 16mm Turret Model Motion Picture Camera are made of NICKEL SILVER powder—for important reasons.

Working with an experienced fabricator,* Revere engineers found that by designing specifically for powder metallurgy, THREE cost-saving advantages could be gained:

. . LOWER MATERIALS COSTS.
The nickel silver sinterings are less expensive than comparable parts produced from extruded stainless steel, the usual material used for similar parts.

. . LOWER PRODUCTION COSTS.
Metal powder sinterings eliminate expensive machining of holes and counterbore operations.

. . LOWER FINISHING AND ASSEMBLY COSTS.
Secondary operations are reduced to a simple drilling of a connecting hole for joining the knob and key and take advantage of the ease with which nickel silver may be given a light satin finish.

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***Materials Selector* is praised . . .**

To the Editor:

You deserve a lot of congratulations for the very excellent 1957-1958 Reference Issue of MATERIALS IN DESIGN ENGINEERING. It is amazingly comprehensive, and it is remarkable that the advertisers have entered into the spirit of the thing and have prepared informational copy . . .

A. O. SCHAEFER
President
Pencoyd Steel & Forge Corp.
Philadelphia

Your recent publication entitled *Materials Selector* is just what I have been looking for . . .

VERNON J. SMITH
Design Weight Engineer
Radioplane Co.
Los Angeles

Now you are doing something worthwhile for old subscribers as well as new. This book shows much effort on your part, and is appreciated.

HOWARD L. COBB
Boonton, N. J.

. . . but there are omissions . . .

To the Editor:

Having some realization of the tremendous amount of labor involved in producing such as your *Materials Selector*, I am extremely hesitant about calling attention to omissions. I have, however, noticed a rather serious omission in your treatment of the stainless steels and have also had it called to **my attention by Mr. Franklin P. Huddle, who is** Materials Conservation Specialist in the Office of the Assistant Secretary of Defense.

We refer to the ferritic stainless steels, of which type 430 is the basic one and which also includes 446, 430F, 430FSE and 405. These are among the first stainless steels developed, and 430 generally has the highest production of any single grade.

Mr. Huddle specifically called my attention to the omission of types 201 and 202 which are the nickel-conserving austenitic types normally associated with 301 and 302.

While I appreciate that there was no attempt made to include all types of stainless steels in your tables, it does seem to me that the more important of the omitted ones might be included in any subsequent edition of the Selector . . .

RICHARD E. PARET
Committee of Stainless Steel Producers
American Iron and Steel Institute
New York City

(more Letters on p 16)

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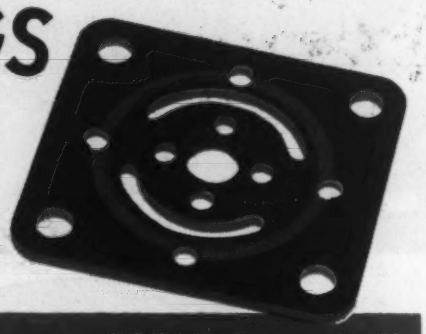

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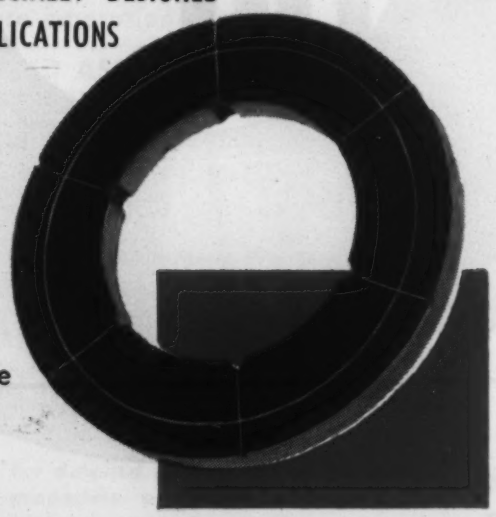

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. . . and there are errors

To the Editor:

Having just received our copy of the *Materials Selector*, I must congratulate you on a wonderful compilation. I am sorry to see, on p 13, the modulus of elasticity in tension of magnesium alloys (cast) given as 650 (x 100,000 psi). The correct value of 65 is given in the right hand column . . .

H. S. BAVISTER
Chief Chemist & Metallurgist
Vauxhall Motors Ltd.
Luton Beds, England

Uranium is listed on p 8 as having a specific gravity of 1.91 but should, no doubt, have been listed as 19.1 . . .

R. MEDITZ
Project Engineer
General Bronze Corp.
Garden City, N. Y.

The *Materials Selector* twice gives the thermal conductivity of cobalt as 479 Btu/hr/sq ft/°F/ft, which is higher than silver or copper . . .

W. L. MARTIN
Alloy Dept.
Owens-Corning Fiberglas Corp.
Anderson, S. C.

These are but a sampling of the letters received which commented on the Materials Selector. *We are grateful for the pats on the back, and doubly so for those which point out errors or suggest valid additions for subsequent issues. The thermal conductivity of cobalt should have been given as 39.9 instead of 479 which is the "per inch" value. An errata sheet will be issued in the near future.*

Translation, please

To the Editor:

Referring to "New Heat Resistant Adhesives for Metal Bonding" by George Epstein in the Jan '55 issue, I would like to know the meaning of an expression I cannot translate exactly into German. On p 109 under the headline "Applying Pressure During Cure," the words "platen press" are used in the first sentence. Is it a hydraulic press or could a platen press also be mechanical?

WERNER MATTHES
Dresden
East Germany

A platen press can be hydraulic or mechanical.

ONE POINT OF VIEW

For progress in science money is not enough

"Is it seriously thought that as long as there are dollars there will be science? . . . As if there were not numberless ingredients, of most disparate nature, to be brought together and shaken up in order to obtain the cocktail of physico-chemical science!"

—Ortega y Gasset

In these days when the demand for more scientists and the concern over our progress in science are matters of wide public discussion, it might be well for us to consider some of the important ingredients needed for successful basic research. Since the launching of Sputnik I, many officials in government, industry, and education have conveyed the impression that more scientists and better basic research can be produced by merely increasing salaries and research budgets.

The mind is not for sale

But the solution to the problem is not as simple as that. Searching and inquiring minds are not commodities and cannot be bought. Nor is financial gain the main incentive for performing basic research. Except for the need for adequate research facilities, money plays a relatively minor role in the field of science. It is not uncommon for research scientists to relinquish their rights to the royalties resulting from their discoveries, or frequently to pass up lucrative opportunities elsewhere to stay in the field of research.

Many factors more important than money affect the quantity and quality of scientists and basic research. There is, for example, the need for a national climate or attitude that is conducive to freedom of inquiry and free exchange of information. And there is the need for respect, trust and confidence in the work of the scientist.

Anti-science in Washington

A review of national policies and attitudes during the past ten years will uncover little evidence that we have tried to meet these needs. Thus, at a time when we could have used the aid of the best scientific minds in the country, Dr. Oppenheimer was declared a security risk even though he was judged completely loyal. Before this incident, Dr. Condon, chief of the National Bureau of Standards, had to face the abuse of the late Senator McCarthy almost alone because top government officials preferred not to risk taking a firm stand in his behalf. And Dr. Condon's successor, Allen V. Astin, suffered an embarrassing experience at the hands of the Secretary of Commerce in the now-famous battery additive case. Also in this case, the Federal Trade Commission disregarded the NBS test results, which were verified by a committee of eminent scientists, and instead accepted the subjective opinions of nonscientists.

These incidents and others like them since World War II reflect a national attitude towards science and scientists that has ranged from complacency to distrust. C. C. Furnas, chancellor of the University of Buffalo, who served as Assistant Secretary of Defense for Research and Development, said in *Life* magazine a few weeks ago: "At a time when Russia was building a scientific elite we were treating our patriotic scientists with hostility and suspicion. No one can accurately estimate the amount of damage that was done."

Reappraisal is due

It is time for a reappraisal of our attitude toward science and scientists. Although spending more money on basic research programs is necessary, this alone will not assure success. The other ingredients—intellectual freedom, unfettered exchange of information, and respect for the scientist's search for knowledge — need an even greater share of our attention.

FEATURE ARTICLES

New Coring Method
Broadens Uses of Light Metal Castings

. . . by simplifying design and reducing the amount of machining required

by John L. Everhart, *Technical Editor, Materials in Design Engineering*

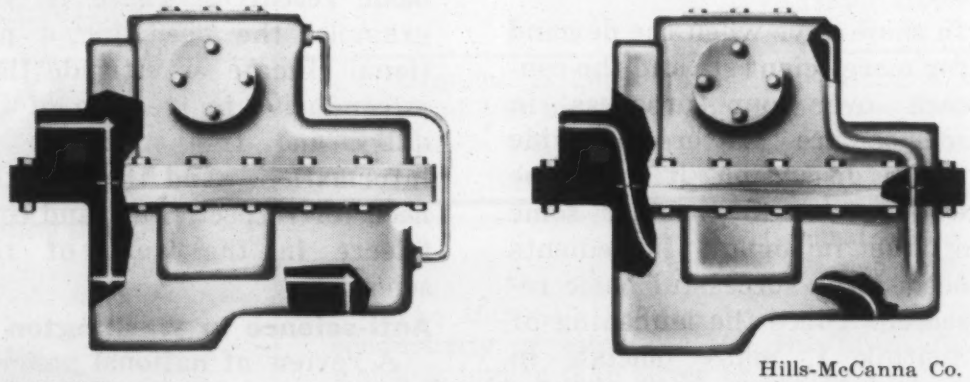
■ Development of methods for introducing small diameter intricate passages into sand cast magnesium and aluminum alloys broadens the range of applications of these castings in handling fluids. Proper design can result in savings in weight, in space and in machining time. The methods also give the designer great freedom in the arrangement of passages and the introduction of highly complex designs.

For example, the path of a cast hydraulic line can be made

Unlined passages vs external connections

The ability to introduce unlined passages into a casting can change complex assemblies into relatively simple ones. In addition to initial savings in tooling, machining and assembly costs, there is often a significant reduction in weight of the assembly. Eliminating external tubing reduces possibilities of damage and simplifies servicing.

As an example, the original design of this aircraft pump called for external tube connections and internal drilled passages. It was redesigned to eliminate the external tubing and to replace drilling by unlined passages. The pump can now be installed with simple connections at the flanged joint, not only reducing the possibility of failures at the tube connections, especially under service conditions involving severe vibration, but also saving considerable weight.



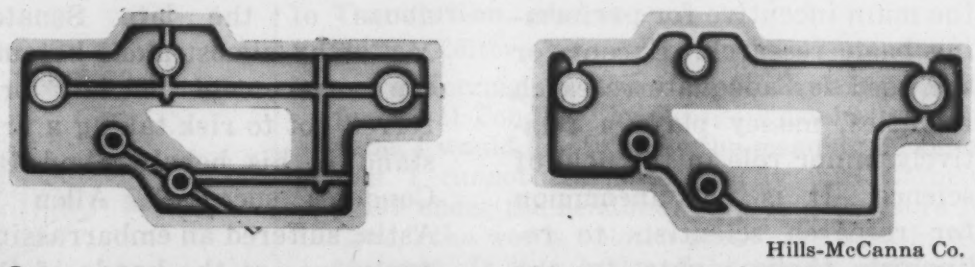
Hills-McCanna Co.

Aircraft pump *employing external tubing and machined passages (left) was redesigned for integrally cast unlined passages (right).*

Unlined passages vs drilling

Drilling of passages has been practiced for many years and is the least expensive method for the production of simple passageways. However, drilling has some obvious disadvantages. Passages must be straight and the drill cannot follow irregular contours. With increasing depth, the drill has a tendency to wander with a resulting increase in the diameter of the passage and the possibility of scrapping the casting for failure to meet tolerances. Complex passages are produced by a series of intersecting straight holes, and it is frequently necessary to tap and plug a hole, thus increasing the possibility of leakage. Connections between two passages will generally be sharp and may be off center. These conditions may cause undesirable turbulent flow.

Unlined passages produced by the methods described are dimensionally accurate, are smooth and generally have radii at points where direction changes. With these characteristics, they offer less resistance to fluid flow than drilled passages.



Hills-McCanna Co.

Gear cover *requiring extensive machining to provide passages for fluid transfer (left) redesigned for integrally cast unlined passages.*

How unlined passages are made

1. Shape core

To prepare the cores, tubing of the proper diameter is shaped over a fixture that introduces the desired configuration. Metal tubes are bent at room temperature and allowance is made for springback. For intricate cores, it is sometimes necessary to make an additional allowance for movement of the tubing during pouring because of the difference in thermal expansion of the tube and the magnesium. Glass tubing is bent hot using special glass forming techniques. The glass is selected to have the proper plasticity in the pouring range to follow shrinkage of the magnesium, yet at the same time resist sagging.

2. Coat core

After the tubing is bent to the desired shape, the metal or glass core receives an additional treatment that varies with the foundry involved. If copper tubing is used, it must be protected from the liquid magnesium; otherwise it will dissolve. Copper tubing is protected by a carbon or thin refractory coating or by a woven stainless steel sheath. The latter is said to be advantageous because it protects the tube, prevents core blows and is used as an indication of complete removal of the tube during inspection. Glass tubing is given a coating to facilitate x-ray inspection.

3. Insert core and pour

Following surface preparation, the tube ends are closed to prevent entry of molten metal during pouring. If desired, the tube assembly can then be combined with sand cores. Pouring of the mold is done in conventional fashion, although care is necessary in the use of glass cores to prevent heat shock.

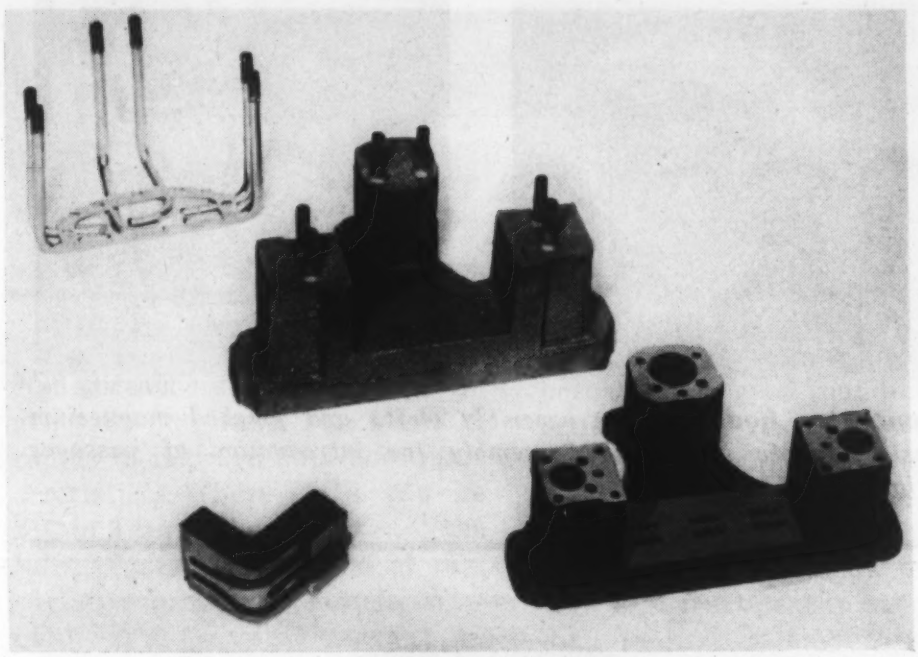
4. Remove core

After shaking out the castings, the tube ends are opened and the tubes are blown out with air to assure a complete passageway. Metal or glass cores are dissolved by passing a suitable acid mixture through them and the castings are inspected.

5. Check core removal

Complete removal of unsheathed metal cores is determined by x-ray inspection. Removal of sheathed metal tubes is determined by withdrawing the sheath and inspecting it. Withdrawal is readily accomplished because the sheath contracts when the tube dissolves; a sleeve fitting a ⅜-in. dia copper tube can be withdrawn readily through a ⅛-in. hole.

Removal of glass tubing is determined by x-ray inspection made possible by the radiographically dense coating that was used in preparing the core; this coating is denser than magnesium and shows up clearly on the x-ray film. Disappearance of the last traces of the coating after acid treatment is proof that the glass tubing has been completely removed.



Fairchild Engine and Airplane Corp.; Rolle Mfg. Co.

***Stages** in the production of unlined passages. **Left**—Core tube assembly. **Center**—Casting after knockout. **Right**—Finished part after removal of tubes and machining. **Lower left**—Cut-away section showing passages. (Photo actually shows production of lined passage, but method is same except for removal of tubes).*

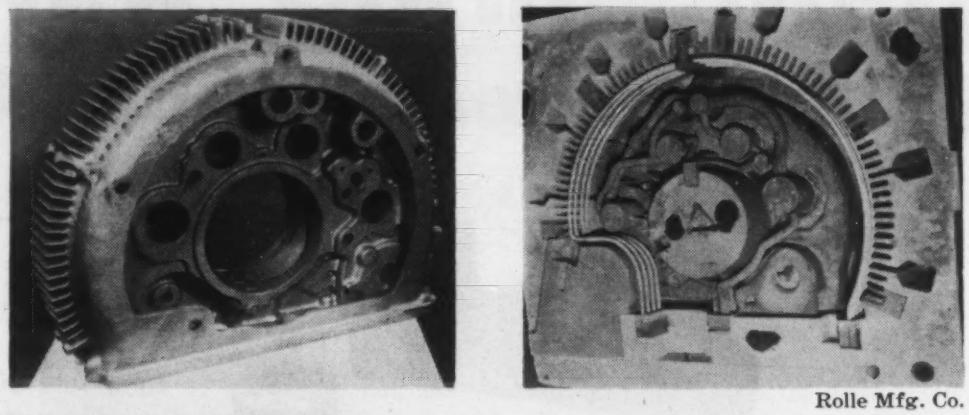
straight, circular or irregularly curved almost as desired. Several independent passages can be introduced for handling fluids of different types. In contrast with passages prepared by machining, these cast passages have smooth walls and may have rounded bends to improve fluid flow.

Primary application has been in the aircraft and missile fields where weight and space are major considerations. Unlined passages have been cast into magnesium and aluminum for hydraulic lines, fuel lines and lubrication lines.

Why a new method?

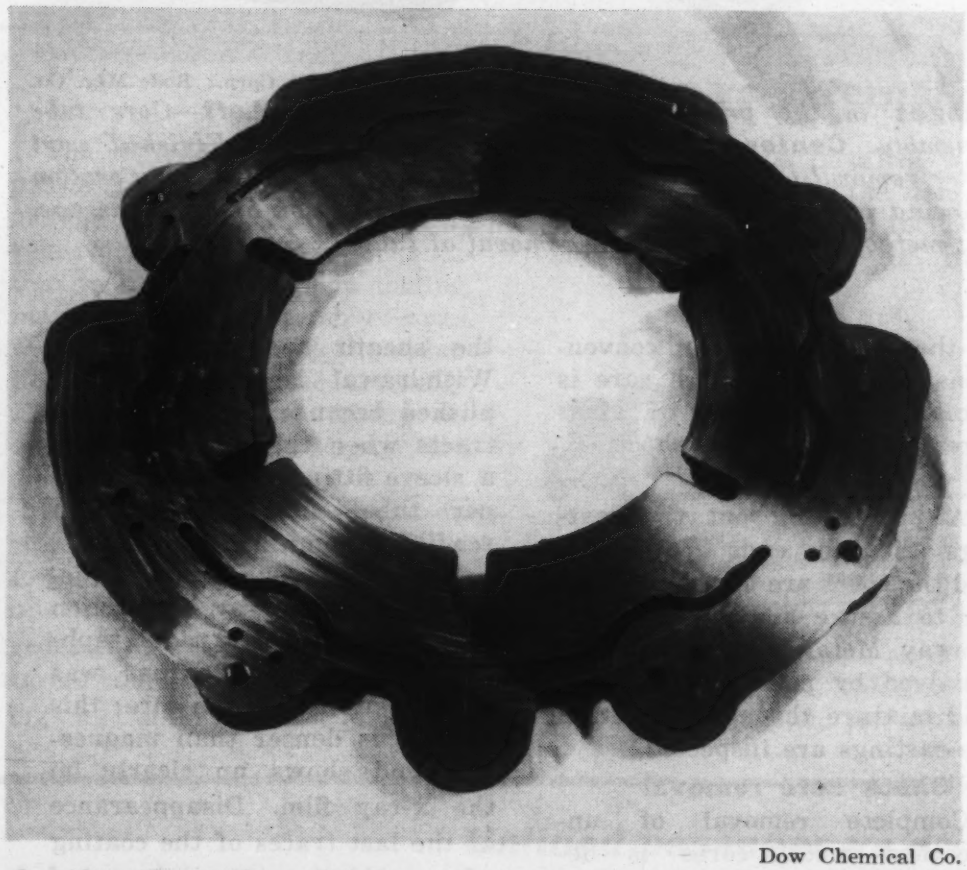
Cavities and passages are commonly made in castings by means of oil or resin bonded sand cores. These must be permeable to allow the gas that is generated when hot metal strikes an organically bonded core to escape through the core rather than through the metal. In small diameter cores, the ratio of length to diameter is large and escape of the gas becomes a problem. Increasing the length of such cores increases the possibility of core blows that result in rejected castings. Possibility of distortion during pouring is also increased. Long, slender cores are difficult to han-

Some applications of new coring method



Rolle Mfg. Co.

Generator housing *core assembly (left) and finished magnesium casting. Note metal tube assembly for introduction of passages (right).*



Dow Chemical Co.

Sectioned casting *showing cast-in tubeless passages. Small holes shown would appear as passages on the mating section of the casting.*

dle and core breakage increases the operating costs. Thus there is a minimum limit to the size of passages that can be introduced into castings by sand coring in commercial practice. For a long core, this limit might be considered as roughly ¼ to ½ in. in dia.

Complex small diameter passages can be produced in aluminum and magnesium castings by using tubing that remains in the casting. Lined passages of this kind are introduced into magnesium castings by using stainless steel tubing as the core. However, there are several problems inherent in the use of these lined passages:

1. Detection of core blows by x-ray inspection is not completely satisfactory.

2. A casting consisting of two metals as different in machinability characteristics as stainless steel and magnesium is difficult to machine.

3. In a corrosive environment, an electrolytic couple may form, with the magnesium acting as a sacrificial anode to protect the steel.

Because of the limitations of lined passages, several methods have been developed to introduce small diameter unlined passages into castings. They involve the use of steel, copper or glass tubing or siliceous cores that are dissolved after the casting has been produced. The methods are described in an accompanying box. By their use, the engineer can design internal passages that save weight and space, and often machining time, as mentioned previously. To take advantage of the possibilities of these methods, however, some consideration of design requirements is necessary.

Design considerations

Certain factors that must be considered in designing castings to contain long unlined passages are given in Table 1. These data were supplied by four foundries.

Although smaller passages have been produced by these new methods, the smallest diameter considered to be commercially practical for long passages at present is ⅛ in. Sizes can range up to 1 in. or above, but generally it is less expensive to use long sand cores when the diameter exceeds about ½ in.; for short lengths, ¼-in. sand cores are often used.

For practical purposes, the unsupported length of a core depends not only on the diameter but also on the design. Unsupported ⅛-in. cores up to 24 in. and ¼-in. cores up to 36 in. have been used. With the metal tube methods a straight core that can be supported rigidly at both ends can usually be longer than one that contains a number of complex bends; the latter may require additional supports. Since increasing the diameter increases the rigidity, large diameter cores can have longer unsupported spans than small cores.

Generally, a passage should be

at least ⅛ in. below the surface of the casting, and two adjacent passages should be separated by about 5/32 in. Circular passages can be flattened as required to maintain desired spacing; for example, a ¼-in. passage can be flattened to a minimum of ⅛ in. Changes in diameter are possible.

Tolerances depend on the individual foundry. Cross-sectional tolerances range from ±0.010 on straight lengths to ±0.020 in. on radii and Tee joints. Location tolerances inside the casting can be held to ±0.030 in. Tolerances at surface openings range from ±0.015 to ±0.030 in.

Although it is possible to make 90-deg corners at joints, it is generally desirable to allow a radius to improve fluid flow characteristics. These radii can be 2½ to 3 times the diameter of the tube. Passages must end at cast surfaces in order to permit entry of the acid used in dissolving the core. Passages can be made of any cross-sectional configuration that is obtainable in tubing form or that can be formed. However, circular or oval cross sections are desirable because they offer minimum resistance to fluid flow.

TABLE 1—DESIGN FACTORS[a]

Commercial Min Dia, in.	0.125
Max Unsupported Length, in.	8 to 24 (⅛-in. tube), 15 to 36 (¼-in. tube)
Min Depth Below Surface, in.	0.125 to 0.1875
Min Distance Between Adjacent Passages, in.	0.060 to 0.1875
Tolerance on Cross Section, in.	±0.010 to ±0.020
Tolerance (Location) Inside Casting, in.	±0.030
Tolerance on Casting Ports, in.	±0.015 to ±0.030

[a]Ranges cover figures given by four foundries.

Editor's Note

This article is based upon a paper by Mr. Everhart given before the Magnesium Assn. Hence, although the method described is applicable to both aluminum and magnesium alloys, the technical details given here apply principally to magnesium.

Materials

Unlined passages can be cast into any magnesium or aluminum casting alloy, the characteristics of the individual alloy determining the ease of production.

The magnesium alloys generally used for this type of casting are listed in Table 2. One producer has no preference; others believe that the alloys containing zirconium and rare earth metals or thorium should be used, although these premium alloys are more expensive than the magnesium-aluminum alloys.

Advantages of the premium alloys are uniform fine grain in heavy and light sections, freedom from microshrinkage and microporosity, and good founding properties. As a result, castings of these premium alloys are pressure-tight as cast. Some of these alloys also have the advantage that they require only a single low temperature heat treatment to attain optimum properties. Therefore distortion during heat treatment is seldom a problem.

Several of these premium alloys also have good elevated temperature properties. EZ33A has a maximum service temperature of about 480 F; HZ32A, a maximum of 680 F. HK31A has a maximum service temperature of about 750 F for short time exposure.

On the other hand, these three alloys have, in general, lower mechanical properties at room temperature than AZ91 and AZ92 (see Table 3). For applications at room temperature, it may be necessary to increase the section thickness to obtain adequate strength if premium alloys are used, thus increasing weight and cost. For this reason, one producer believes that impregnating castings of AZ91 and AZ92 is often more desirable, from both cost and weight viewpoints, than employing the premium alloys.

TABLE 2—NOMINAL COMPOSITION OF MAGNESIUM ALLOYS USED (%)

Alloy (ASTM) ↓	Al	Zn	Mn	Rare Earths	Th	Zr
AZ91C	8.7	0.7	0.13	—	—	—
AZ92A	9.0	2.0	1.15	—	—	—
EZ33A	—	3.0	—	3.25	—	0.7
ZE41A	—	4.25	—	1.2	—	0.7
HZ32A	—	2.1	—	—	3.25	0.5 min
HK31A	—	—	—	—	3.25	0.7
ZH62A	—	6.2	—	—	1.8	0 5 min

TABLE 3—MECHANICAL PROPERTIES OF MAGNESIUM ALLOYS USED

Alloy (ASTM) ↓	Temper	Tensile Strength, 1000 psi	Yield Strength, 1000 psi	Elongation, %
AZ91C	T 6	40.0	21.0	6
AZ92A	T 6	43.4	26.0	2
EZ33A	T 5	23.0	16.0	3
HZ32A	T 5	30.7	17.1	5
HK31A	T 6	30.8	16.2	6
ZE41A		30.0	19.0	3
ZH62A	T 5	40.0	25.0	10

Source: *M. W. Mote and R. J. Jackson.*

References

ASTM Standards, Part 2, Non-Ferrous Metals, 1956 Supplement. American Society for Testing Materials, Philadelphia, Pa.

Dalton, R. F., "Forming Intricate Passageways with Removable Sheathed-Tube Cores." *Modern Castings*, May '57, p 91.

Mote, M. W. and Jackson, R. J., "Magnesium and Its Alloys," MATERIALS IN DESIGN ENGINEERING, July '57, p 115.

Acknowledgments

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Dow Chemical Co.
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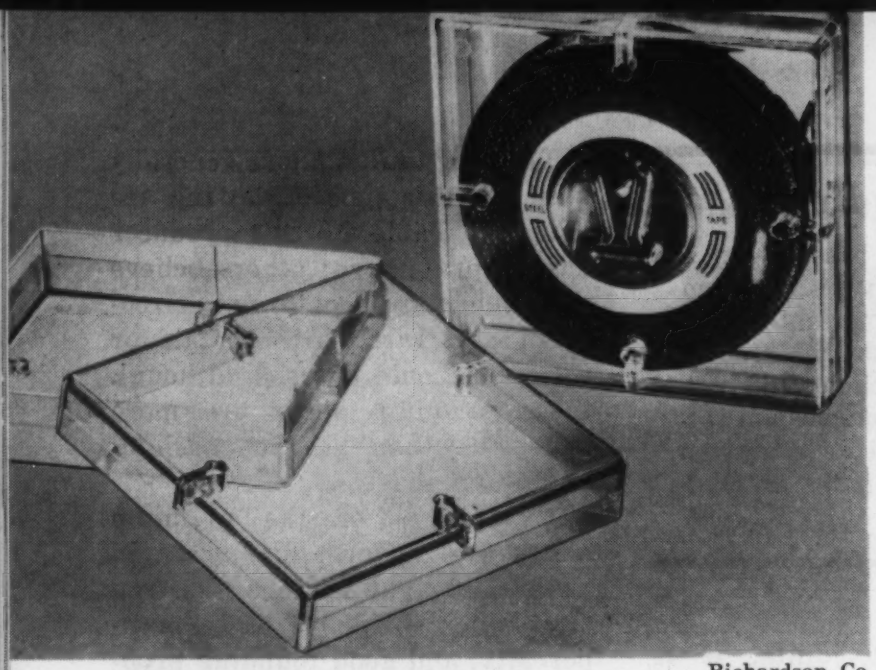
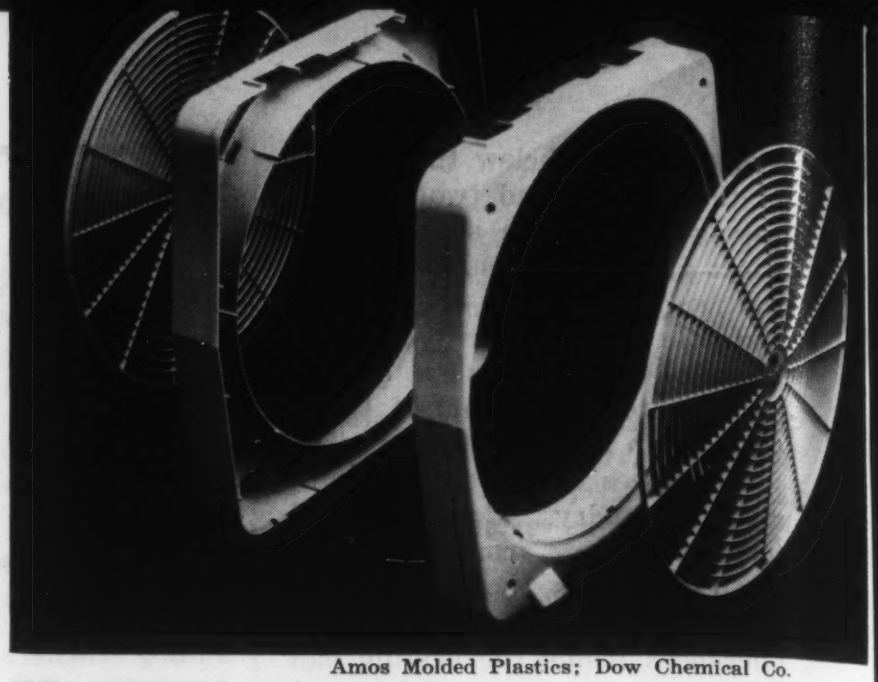
Rolle Mfg. Co.



Richardson Co.

Polystyrene—*General purpose polystyrene can be injection molded to provide crystal clear transparent parts such as this display container for a metal tape.*



Amos Molded Plastics; Dow Chemical Co.

Modified styrene—*Large, complex, load-bearing parts can be injection molded of modified high-impact polystyrene. The housing for this 20-in. fan provides particular economies, since tooling is such that front and back of the housing were produced from the same mold.*

Designing for Injection

This article gives the information you need to select the right thermoplastic material and to design properly for the high production injection molding process.

■ Injection molding is a high speed method of producing moldings in thermoplastic materials. Since the high production rate requires permanent molds which may range in cost from $1500 to $30,000 the process is normally used where production volume is to be high, thus reducing per-part tooling costs as much as possible.

Recent developments in moldability of materials and injection molding equipment have broadened the size range of moldings possible, increased the complexity of design possible, and increased production rates by reducing cycle times. Sizes of moldings may range from a fraction of an ounce up to 9 or 10 lb. Sections can be extremely thin, and thin-walled (0.014 in.) parts can be produced at rates of 1400 pieces per hour. Large area, heavy parts are currently produced on 75- to 90-sec cycles.

Materials

The initial selection of the thermoplastic resin for a molding is usually made on the basis of physical, mechanical or chemical property requirements and appearance. After preliminary selection it is usual to consider the material cost in terms of yield per pound (for relationship of specific gravity to cost, see accompanying table on costs).

The following discussion of thermoplastics is intended only to summarize the most important characteristics of each type of molding material.

Acrylics—Acrylics or polymethyl methacrylates are probably best known for their optical clarity and crystal color. They have excellent resistance to weathering and ultraviolet light exposure and thus are suitable for outdoor use.

Acrylic injection molding compounds are supplied in several grades, varying in flow characteristics and heat resistance. In general, the higher heat resistant grades have lower flow characteristics, and thus lesser moldability.

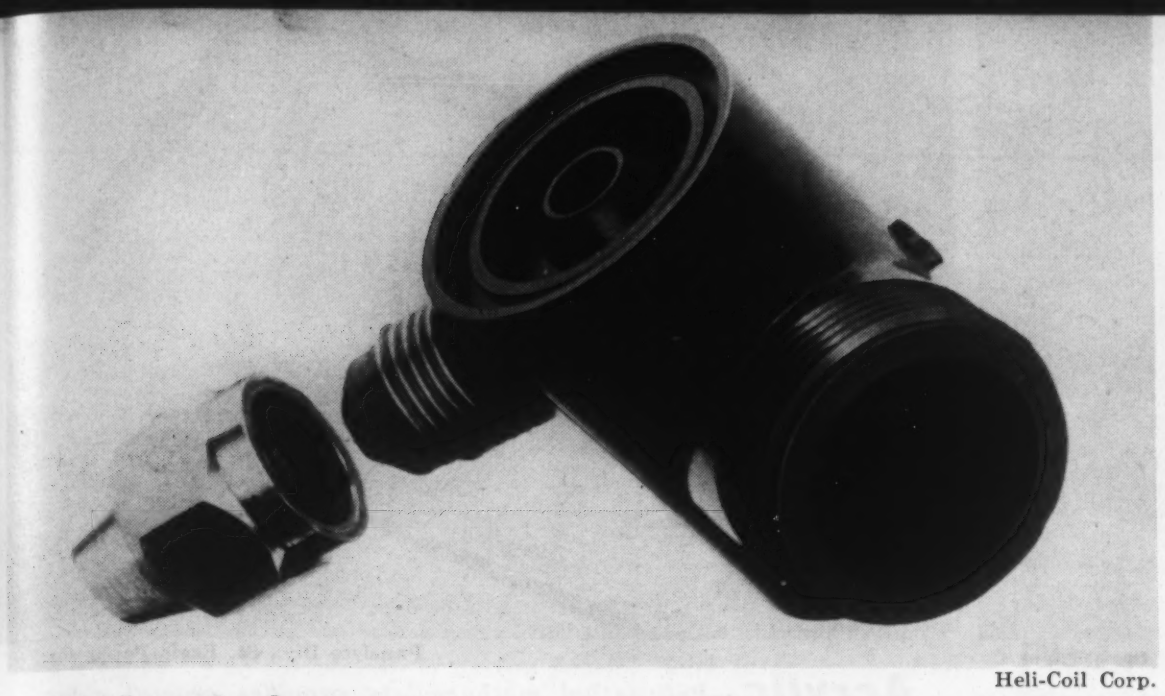
Typical applications for acrylics include television lenses, auto taillight lenses, sign letters, escutcheons and name plates.

Cellulosics — This term covers many polymers made from cotton linters in combination with other chemicals. The cellulosics are noted for toughness, colorability, and ease of molding and fabricating.

Cellulose acetate has good gloss and moldability and is available with a range of heat distortion

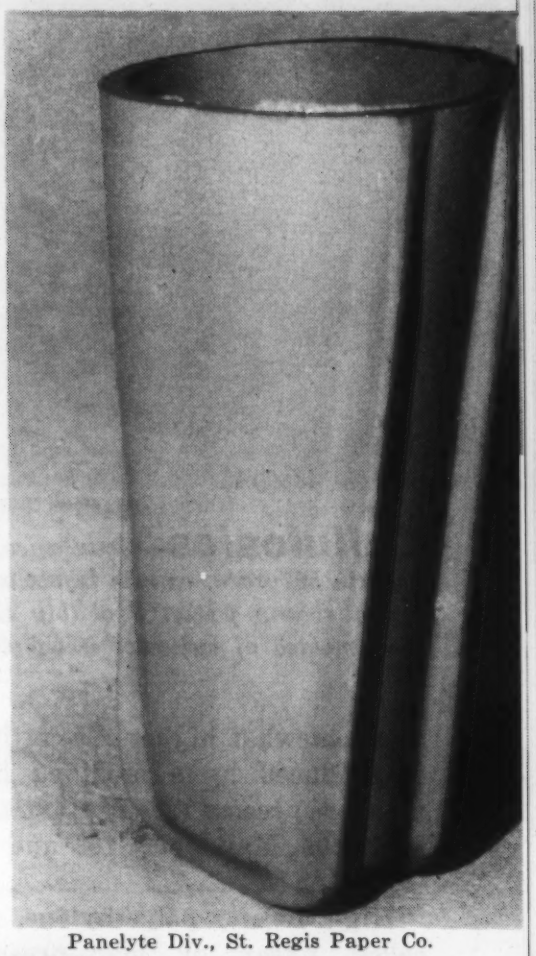
Second of Series

This is the second of a series of two articles on plastics moldings. The first, "Designing for Compression and Transfer Moldings," appeared last month, p 126.



Heli-Coil Corp.

Polyethylene—*Injection molded hydraulic fittings, shown with molded wire thread inserts, permit assembly of complete polyethylene pipe systems.*



Panelyte Div., St. Regis Paper Co.

PVC—*Though most commonly extruded, calendered or slush molded, polyvinyl chloride can be readily injection molded to form parts such as this scuff protector for chairs.*

Molded Plastics

by John R. Kent, *Technical Service, Monsanto Chemical Co.*

temperatures from 130 to 210 F, and flow characteristics ranging from "double soft" to "double hard." Typical applications include toys, machine housings and film.

Cellulose acetate butyrate is a modified cellulose acetate providing lower moisture absorption, better dimensional stability and slightly higher heat distortion temperatures. It also has improved resistance to ultraviolet light, making it more suitable than acetate for outdoor use. Butyrate has been most widely used for telephone handsets, auto steering wheels and parts where the degree of water absorption inherent in cellulose acetate cannot be tolerated.

Cellulose propionate is a tough, hard cellulosic with particularly good flow characteristics. A number of grades are available, enabling the molder to balance desirable molding characteristics with the physical properties required in the molding.

Ethyl cellulose has high dimensional stability, toughness and resilience, but is more costly than the other cellulosics. It has been used for Signal Corps field handsets which are required to take rigorous abuse.

Chlorotrifluoroethylene (CFE)—Commercially known as fluorothene, Kel-F, Polyfluoron or Genetron HL, CFE is a relatively tough material with extremely good resistance to chemicals and heat (maximum recommended service temperature is 390 F), and excellent dielectric characteristics.

Special technology and molding know-how have been developed to handle the high molding temperatures of about 500-620 F. However, conventional injection molding equipment is used.

Though these materials are high in cost, the premium properties inherent in them are causing them to be used increasingly in electronics, aircraft and ordnance applications.

Nylon—Members of the polyamide family, nylons are extremely tough, abrasion resistant, self-lubricating and available in grades that will withstand temperatures in excess of 212 F. The most common nylon is designated type 6/6. Type 6, or caprolactum, nylon has improved moldability, at some sacrifice in properties.

Nylon is widely used for applications such as gears and other parts for computing devices and automobiles, and for fasteners, grommets and hardware components.

Polyethylene—In production volume polyethylene has become one of the fastest growing of the plastics polymers. The low density or conventional materials are tough, resilient, and relatively easy to mold and fabricate. Polyethylenes are available with a wide variety of design properties. Density of the material (a measure of crystallinity) is used to classify polyethylenes into three broad groups: low density (0.912-0.925 gm per cu cm); medium density (0.926-0.941); and high density (0.942-0.965).

Medium density polyethylene is more crystalline than the conventional types and thus has greater rigidity, improved heat resistance

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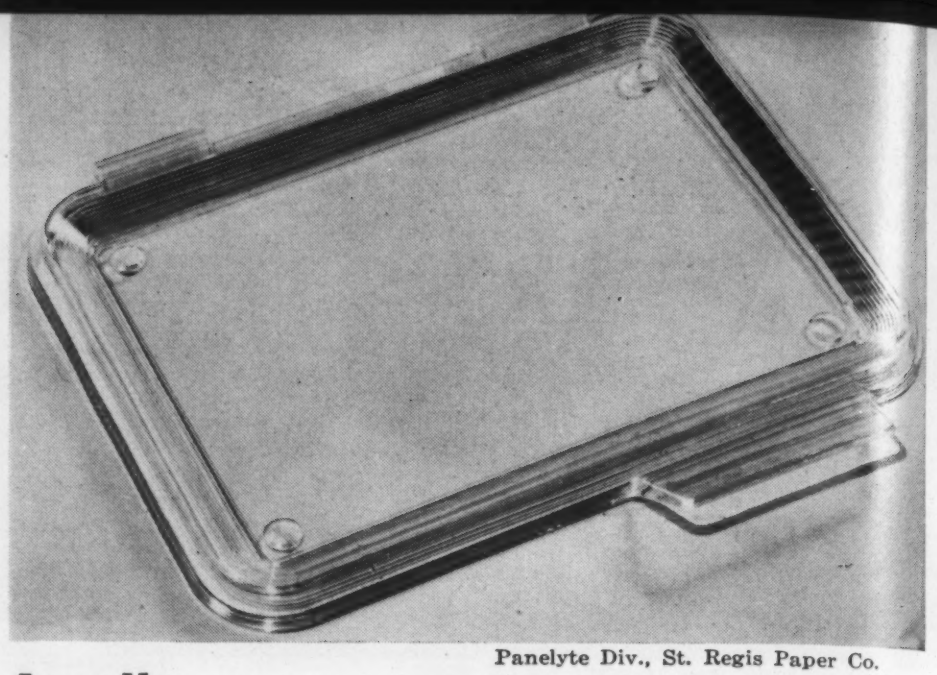
Cellulosics—*Cellulosics, such as cellulose acetate butyrate, can be injection molded to form tough strong parts. Probably the most familiar part molded of butyrate is the telephone handset.*



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Acrylic—*Polymethyl methacrylate provides crystal clear parts, such as this injection molded vending machine door.*

and somewhat higher strength. It is produced by a modified high pressure process (see MATERIALS & METHODS, May '56, p 165 and Oct '56, p 145).

High density polyethylene, also called linear or low pressure polyethylene, is evn more crystalline in nature than the medium density material, and has maximum rigidity, heat resistance and strength (see MATERIALS & METHODS, July '55, p 88).

Applications for polyethylene include squeeze bottles, electrical insulating components, pipe, housewares and toys.

Polyvinyl chloride — Polyvinyl chloride, or PVC, particularly noted for its resistance to petroleum oils, can be compounded to a wide range of flexibilities. Though PVC is usually produced by extrusion or calendering, parts such as gaskets or electrical insulating parts are produced by injection molding.

Styrene—The largest volume of injection molded thermoplastics is made up of polystyrenes, which include several modified and "alloyed" styrene materials. Styrenes in general have excellent moldability, dimensional stability, superior dielectric properties and good surface characteristics.

General purpose styrenes are available in a variety of colors and with varying heat distortion and flow characteristics. They are used for television lenses, escutcheons, refrigerator components and a variety of packaging applications.

Rubber-modified styrenes (modified with SBR or NBR) have higher impact strength than general purpose styrene and have greater toughness and abuse resistance. No truly transparent rubber-modified styrene is available. Light transmission ranges from highly translucent to opaque, depending on section thickness and the rubber used. For further improvements in toughness and chemical resistance, rubber modified styrenes are combined with acrylonitrile. Such materials have the good dimensional stability of other styrenes, but are more costly than the high impact styrene polymers.

Where chemical resistance superior to that of general purpose styrene is required, styrene-acrylonitrile copolymers are available. Slightly yellow in their natural form, such materials are used primarily for water tumblers, hair curlers and applications requiring resistance to organic solvents.

Also available are specialty styrenes which have been stabilized for resistance to ultraviolet light for use in lighting installations.

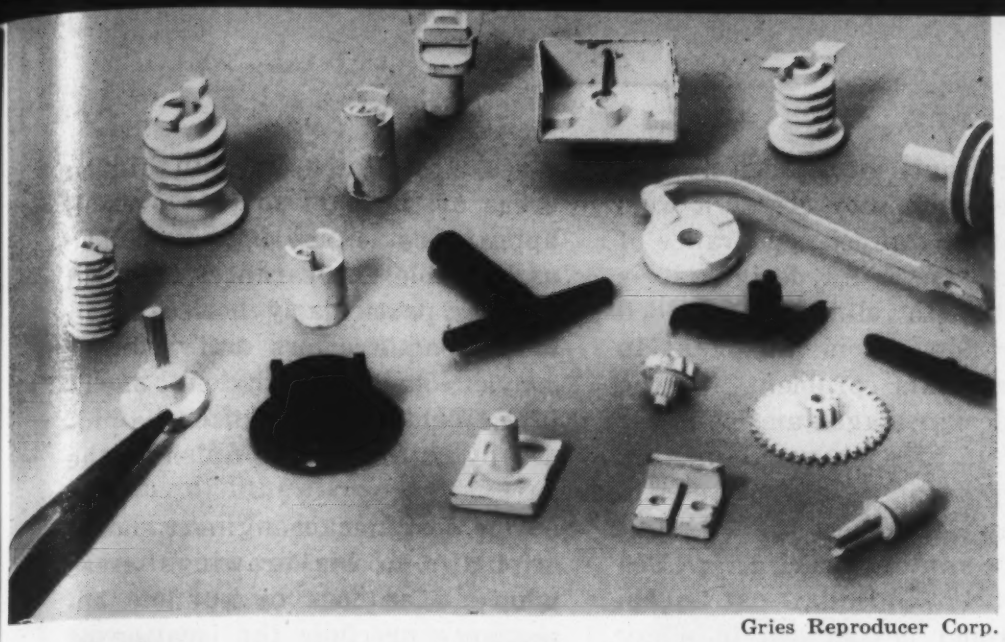
Methylstyrene, a substituted styrene polymer, and methylstyrene-acrylonitrile copolymer were developed about two years ago (commercial production just recently announced) for applications where the conventional properties of styrene are required, but higher heat resistance is needed. Though the materials have heat distortion temperatures of about 210 F, they can be subjected to boiling water with very little subsequent distortion.

Glass-filled thermoplastics—Both polystyrene and nylon molding materials reinforced with chopped glass fiber rovings are available for injection molded

The Process

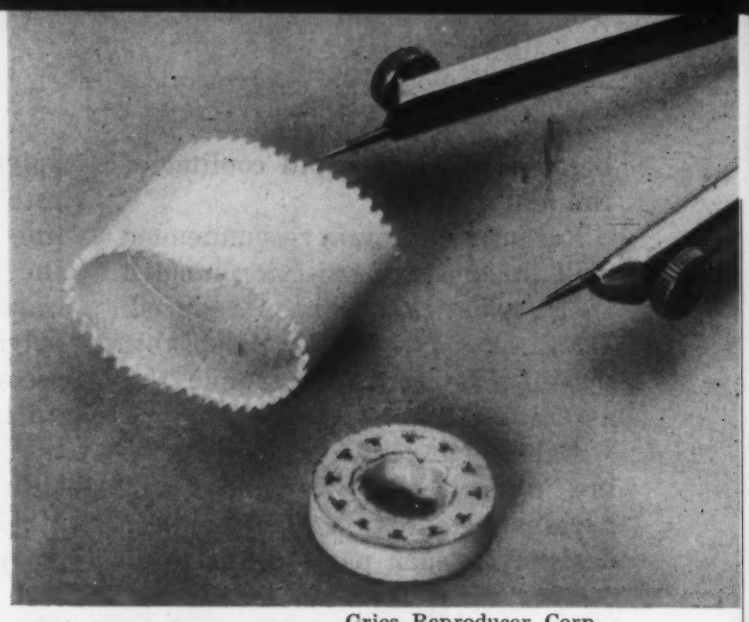
In general terms, injection molding is to plastics what die casting is to metals. Small pellets or granules of the thermoplastic molding material are fed mechanically into a softening or heating chamber where they are heated to a molten state. Once softened the polymer is subjected to hydraulic injection pressure and forced into the closed mold cavity or die. Hydraulic pressure supplied by the injection ram may vary between 20,000 and 30,000 psi, though after losses in the system, the actual injection pressure on the polymer may vary from 1500 to 10,000 psi.

After the cavity is filled by the molding material it is allowed to cool, solidifying the molding. The mold is then opened and ejector pins eject the part from the mold. Dies may be of the single or multiple cavity type, fed through sprues, runners and gates.



Gries Reproducer Corp.

Nylon—*The complexity of design possible with injection molding is indicated by these small nylon parts for timers, switches, cameras, model railroad trains, pens and ignition systems.*



Gries Reproducer Corp.

Fluorocarbon — *CFE (chlorotrifluoroethylene) provides essentially zero moisture absorption and extremely good electrical qualities for injection molded coil bobbins and switch rotors.*

parts. The reinforcements improve shock resistance, tensile properties and dimensional stability.

Design considerations

The successful complete design of a part for injection molding can usually be accomplished only when materials selection and design are considered in terms of the following basic factors:

1. Function of part
2. Style requirements
3. Ease of molding
4. Tool design
5. Post-molding finish
6. Assembly
7. Packaging and shipping
8. Cost

Any or all of these may influence the selection of the proper material and the most successful design. At the initial design level the designer or engineer should consult with the molder to determine the optimum material and shape in order to keep tooling costs to a minimum, insure maximum production output and obtain the highest quality product.

COMPARATIVE COSTS OF THERMOPLASTICS

Material ↓	Type	Base Price, $/b[a]	Specific Gravity (molded)	Volumetric Price, ¢/cu in.
Styrene[b]	Clear	0.25	1.05	0.91
	Colors	0.28	1.06	1.07
Modified Styrene	Natural	0.32	1.07	1.23
	Colors	0.345	1.07	1.33
Polyethylene (low density)	Natural	0.35	0.915-0.930	1.16-1.17
	Colors	0.44		1.45-1.48
Polyethylene (high density)	Natural	0.47	0.95-0.96	1.61-1.63
	Colors	0.50		1.71-1.75
Vinyls	Colors	0.27-0.42	1.30-1.38	1.27-2.1
Cellulose Acetate	Clear	0.50	1.3	2.35
	Translucent Colors	0.46	1.3	2.16
	Opqaue Colors	0.36	1.3	1.69
Acrylics	Clear	0.55	1.18	2.36
	Colors	0.59	1.18	2.51
Glass-Filled Styrene	Natural	0.55	1.32	2.62
	Colors	0.65	1.35	3.17
Cellulose Acetate Butyrate	Clear	0.62	1.28	2.87
	Colors	0.62	1.28	2.87
Ethyl Cellulose	Colors	0.72	1.15	2.99
Cellulose Propionate	Colors	0.63	1.23	2.80
Polyamides	Natural	1.33	1.14	5.48
	Colors	1.63	1.14	6.72
Chlorotrifluoroethylene	Natural	6.00-7.50	2.1	45.48-56.85

[a]Prices are those prevailing at time of writing. Carload prices are used.
[b]General Purpose grade.

It is impossible to set down a rigid set of rules for design of injection molded parts, but experience has shown that the following recommendations are generally applicable.

Draft or taper—Usually a draft of ½ to 1 deg per side is required to remove the part from the mold; however, parts with a high ratio of depth of draw to projected area may require more draft. The material being molding can affect necessary draft (e.g., polyethylene often requires 2 deg), and the toolmaker should be consulted before the design is fixed.

Fillets or radii—Sharp, inside corners lead to stress concentrations which can weaken the part. Also, it is often less expensive to machine a radius than a corner when building the mold. A radius of 25% of the wall thickness is the usual minimum for good design, with 1/32-in. fillets as a desirable minimum.

Wall thickness—Wall thickness of industrial parts may range from about 0.0625 to 0.250 in. for rigid or semirigid materials such as styrene, the cellulosics, and polyethylene. Acrylic and styrene hairbrush backs have been over 1 in. thick. Other things being equal, generally the thinner the wall thickness the faster the cycle

because of more rapid cooling of the material.

Recently minimum recommended wall thickness of injection molded thermoplastics has been reduced. Wall sections of 7-oz disposable polystyrene cups, for example, are as thin as 0.014 in.

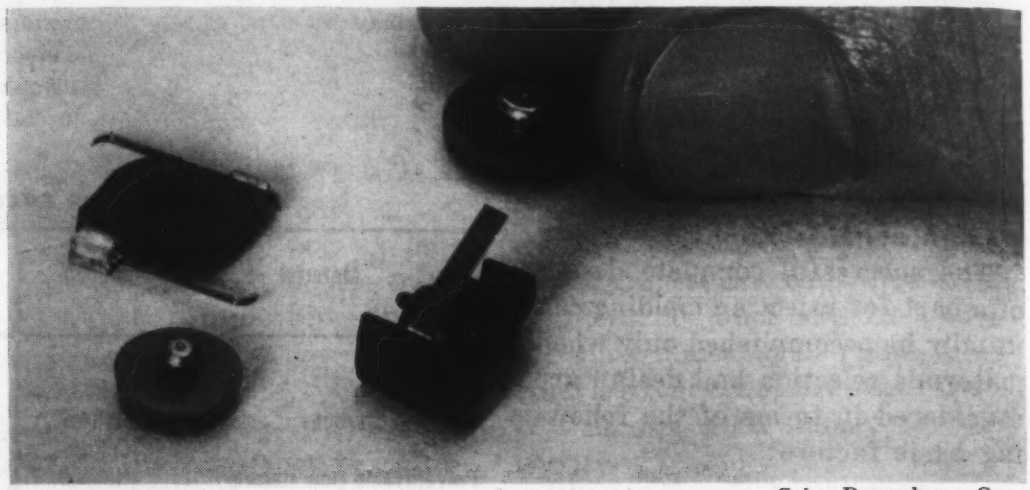
Rapid changes in wall thickness are undesirable, but are often necessary to obtain the required design. In such parts differential cooling rates can cause undesirable "sink marks" on the surface of the molding.

Ribs—Generally, wall thickness of a rib should be limited to 50% of the wall thickness of the part at the base of the rib. Where mold construction permits, localized mold cooling can aid in eliminating a "sink" which might otherwise occur at this point.

Undercuts—Though undesirable from a molding standpoint, with some materials certain shallow undercuts can be incorporated without special camming or split molds. If the molding material has a certain degree of elongation, such parts can be "stripped" from the mold. In rigid materials an elongation of about 10% is sufficient for some shallow undercuts.

Surface quality—If two molten polymer fronts meet when flowing into the mold, they create a weld line that may affect appearance of the part. In many designs it is impossible to eliminate divided polymer flow. It is important to recognize this problem in the initial design stages and consider the effects of such weld lines on both appearance and strength. Molding techniques can be employed to minimize such weld lines and provide adequate strength. Also, proper design can in many cases locate such lines in hidden areas of the part so that over-all appearance is not impaired. The undesirable appearance of weld lines is particularly noticeable in dark opaque colors and in most conventional polyethylene moldings. Weld lines can often be hidden by using a matte finish on the part.

The designer or engineer should stipulate on his drawings areas where tolerances or surface appearance preclude the location of



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Intricate inserts *can be molded-in during the injection molding cycle, as shown by these four parts. Top left is IBM brush and insert assembly incorporating die cast zinc core with 12 wire strands in black nylon. Upper right and lower left are ethyl cellulose insulator caps incorporating brass electrical contacts. Lower right is an automatic coupler knuckle for model railroad. It incorporates spring temper bronze in black nylon.*

GENERAL PROPERTIES OF

Plastic ➡	ASTM Method	Acrylics	Cellulosics				Chlorotri-fluoroethylene	Nylon
			Acetate	Butyrate	Propionate	Ethyl Cellulose		
Specific Gravity	D792	1.18-1.19	2.0-2.6	1.15-1.25	1.18-1.24	1.10-1.16	2.1	1.09-1.14
Tensile Strength, 1000 psi	D638	7.5-10	2.4-8.5	1.9-6.8	1.5-7.5	3-7	4.5	6.1-12
Flexural Strength, 1000 psi	D790	13-17	No breaks	No breaks	No breaks	4-10	—	No breaks
Impact Strength (Izod), ft-lb/in.notch	D256	0.4-0.6	0.4-5.2	0.6-5.4	0.8-11.0	1.7-7.0	3.6	0.6-4.0
Heat Distortion Temp (264 psi), F	D648	150-205	111-235	121-210	100-190	120-160	390[k]	135-150
Water Absorption (24 hr), %	D570	0.3-0.4	1.9-6.5	1.1-2.2	1.2-2.0	0.8-2.0	0.00	0.4-1.6
Flammability (>0.050 in.), ipm	D635	1.0[a]	0.5-2.0[d]	0.5-1.5[d]	1.0-1.5	0.5-1.5	Non-flammable	Self-extinguishing
Color Range		Crystal and all colors	Crystal and all colors	Crystal and all colors	Crystal and all colors	Crystal and all colors	Translucent and opaque	Opaque[f]
Surface Gloss[b]		1	1	1	1	1	2	2
Dielectric Strength (short time, ⅛ in.), v/mil	D149	450-500	250-365	250-400	300-450	350-500	450	385-470
Dielectric Constant (60 cps)	D150	3.5-4.5	3.5-7.5	3.5-6.4	3.6-3.9[e]	3.0-4.5[e]	2.65	3.8-7.6
Dissipation Factor (60 cps)	D150	0.04-0.06	0.01-0.06	0.01-0.04	0.006-0.01[e]	0.002-0.020	0.015	0.01-0.09
Arc Resistance, sec	D495	[c]	50-310	—	175-190	150-200	>360	130-140

[a] ¼ in. thickness.
[b] Comparative rating: 1 = best.
[c] Does not fail. Arc ignites gases produced by heat; no carbonized path is produced.
[d] Self-extinguishing grades are available.
[e] 1000 cps.
[f] Clear films are available.
[g] Unmodified resin moldings can be ignited and burn slowly.
[h] Melts locally; part may distort due to heat.
[i] Ranges include both General Purpose and Electrical grades.

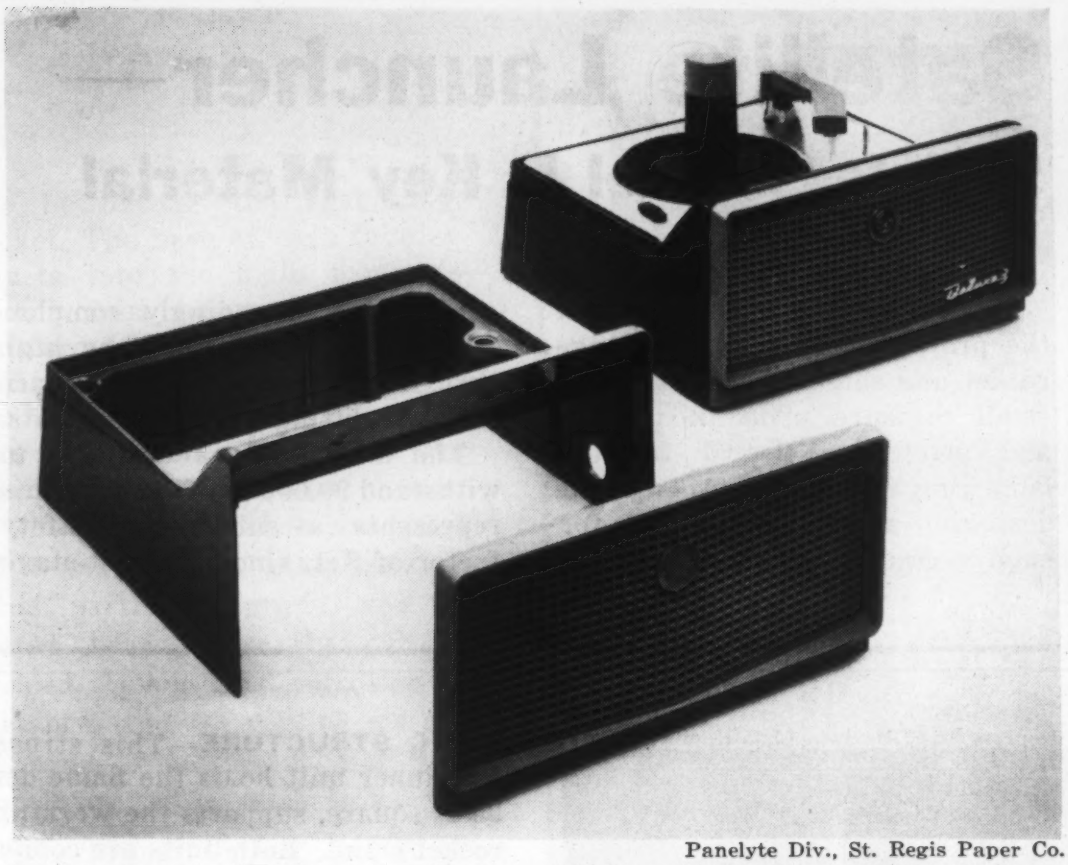
parting lines, gates or ejector pin marks.

Holes—Both through and blind holes can be molded into the part. A designer should consider whether the additional cost of incorporating cam action into the mold would be more or less economical than the cost of post-molding drilling.

Threads—Internal and external threads can be incorporated in the molding by means of special devices in the mold. Such devices add to the tooling cost and reduce production rate. Generally, sharp threads are not recommended. Thread depth should be limited to 75% of ASA or SAE design.

Inserts — The most common types of inserts are shafts, bushings or wire threads. Differences in coefficients of expansion between the plastics molding material and the metal inserts must usually be considered and accounted for in design. For example, the coefficient of expansion of polystyrene is four times that of brass; upon cooling, the styrene will shrink more than the brass and could crack around the insert.

The required thickness of plastic around the insert will vary with the material being molded. Materials with higher elongation usually require less material around the insert. An excellent and quite complete discussion of inserts is contained in the *Plastics Engineering Handbook* of the Society of the Plastics Industry.



Panelyte Div., St. Regis Paper Co.

***Dimensional accuracy** as well as complexity of injection moldings is shown by the good fit between the two high impact styrene moldings making up the case for this photograph.*

Tolerances — Specifying tolerances closer than absolutely necessary always increases the cost of moldings. The closer the tolerances the more costly the part.

Tolerance tables showing graphically specific tolerances obtainable on various dimensions of a typical molding using various molding materials are published in the *Plastics Engineering Handbook*. The thermoplastics materials covered are:

1. Cellulose acetate: medium flow.
2. Cellulose acetate butyrate: medium flow.
3. Ethyl cellulose.
4. Methyl methacrylate: general purpose and heat resistant.
5. Polyethylene: general purpose (conventional).
6. Polystyrenes: general purpose and heat resistant; styrene-acrylonitrile copolymer; styrene-butadiene copolymer.
7. Nylon (FM 3001 and FM 1001).
8. Polyvinyl chloride: Type A in durometer hardnesses of 70, 80, 90 and 100.

THERMOPLASTIC MOLDINGS

	Polyethylenes			Polyvinyl Chloride[i] (nonrigid)	Styrenes	
	Low Density	Medium Density	High Density		General Purpose and Heat Resistant	Modified
Specific gravity	0.912-0.925	0.926-0.941	0.942-0.965	1.15-1.65	1.05-1.08	1.0-1.10
Tensile strength, thousands of psi	1.5-2.4	1.6-2.5	2.5-5.0	1.4-3.0	4.5-9.5	3-12
Elongation, %	No breaks	No breaks	No breaks	—	8-15	10-12
Izod impact, ft-lb/in. of notch	Incomplete break	Incomplete break	1.0-10	—	0.25-0.6	0.3-11.0
Deflection temperature, °F at 264 psi	—	—	—	—	155-210	160-220
Water absorption, % in 24 hr	<0.02[g]	<0.02[g]	<0.02[g]	0.20-2.25[j]	0.03-0.06	0.05-0.30
Mold shrinkage, in./in.					0.5-2.0	1.5-11.0
Optical properties	Translucent and opaque	Translucent and opaque	Translucent and opaque	Translucent and opaque	Crystal and all colors	Translucent and opaque
Burning rate, in./min	3-4	3	2	2	1	2
Dielectric strength, volts/mil	480	480	480	700-1000	500-700	300-650
Dielectric constant at 10[6] cycles	2.3	2.3	2.3	3-11	2.5-2.65	2.5-4.0
Power factor at 10[6] cycles	<0.0005	<0.0005	<0.0005	0.03-0.13	10-50 x 10^{-5}	0.4-140 x 10^{-3}
Effect of sunlight	Melts	Melts	Melts	—	40-100[h]	60-110[h]

[i]Slow burning or self-extinguishing.
[k]Maximum recommended service temperature.
Source: Adapted from *Technical Data on Plastics*, published by Manufacturing Chemists Assn., 1957.

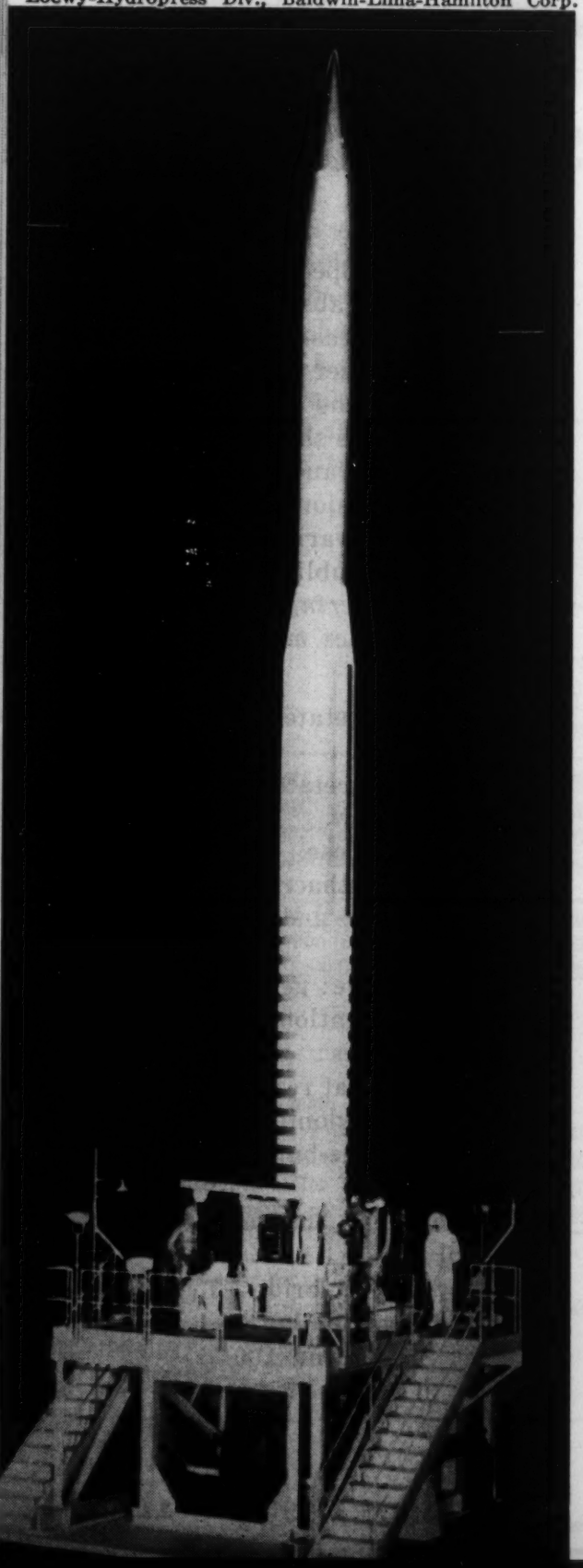
Satellite Launcher—
Stainless Steel is Key Material

Success or failure in launching the project Vanguard three-stage rocket and satellite depends in no small measure upon the design and materials selected for the launching stand. The problems of designing a suitable launcher for such a heavy and large (72 ft) vehicle are exceedingly complex, particularly in view of the high thrusts and temperatures that are involved during static firing tests.

The launcher was designed to withstand 90,000 lb of thrust. This represents a substantial safety factor of 3:1, since the first-stage engine is not expected to develop over 30,000 lb thrust. Components of the launcher are specified to withstand temperatures of 5000 F for short periods. Actual temperature generated by the main engine is expected to be about 4000 F.

Working from the ground up, the basic components of the launcher are: 1) basic structure and exhaust deflector tube, 2) rocket stand and load cell system, 3) steam jet deflector tubes, 4) engine retention tripods, and 5) swing-away units.

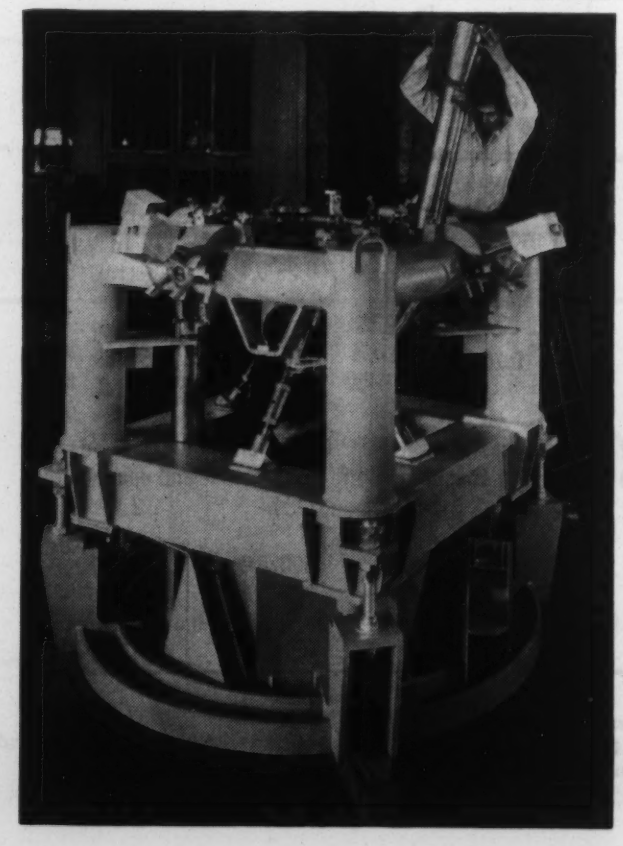
Loewy-Hydropress Div., Baldwin-Lima-Hamilton Corp.



BASIC STRUCTURE—This structure is actually a nest of two units. The inner unit holds the flame deflector tube, and the outer unit, about 20 ft square, supports the working platform, which in turn supports the rocket stand. Both units are connected to a concrete pad by sunken bolts. The working platform is made up of a 2-in. thick steel plate covered with a ¼-in. checkered steel plate. The plates are sloped so as to drain any spilled propellants or other liquids off into the main exhaust tube.

The design of the large curved flame deflector tube is somewhat unique. Its purpose is to divert the main engine exhaust from a vertical to a horizontal direction. To prevent the tube from overheating, its walls are cooled by high pressure water entering through hundreds of small holes.

ROCKET STAND AND LOAD CELL SYSTEM—The rocket stand and SR-4 load cell system comprise an integral unit which sits on top of the working platform. The load cell system forms the base of the unit and is attached to a weigh-ring on the platform. Primary purpose of the sys-stem is to measure engine thrust during static firing tests and to weigh the rocket and fuel.



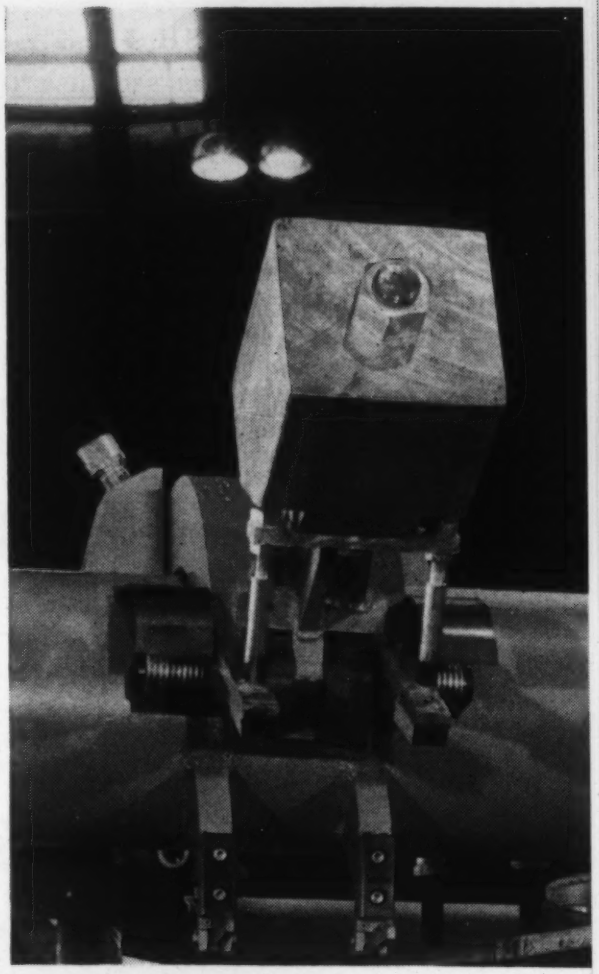
The rocket stand itself is the heart of the launcher. Its purpose is to act as the immediate support for the rocket and to house the engine hold down members and steam jet deflector tubes.

The structure is 6½ ft square and is made up of 8- and 12-in. steel pipe and stress relieved structural steel. All small carbon steel parts of the stand are cadmium plated to prevent rusting.

DEFLECTOR TUBES — Two all-stainless steel deflector tubes (see photo) within the rocket stand divert the high pressure, high temperature (800 F) steam blast from the small rotating jets at the bottom of the first stage rocket. The base of each tube exhausts into the main flame deflector tube below the working platform. The steam jets can be rotated and, through their compensating reaction, help to control any lateral motion or roll that the rocket develops.

The deflector tubes are made of 16-gage type 347 stainless steel. This particular grade was selected because it: 1) can be welded, 2) has good corrosion resistance, and 3) retains its mechanical properties at high temperatures. This grade is used in other high temperature applications such as airplane exhaust stacks, collector rings and jet engine parts.

ENGINE RETENTION TRIPODS — These two tripods (see photo) are located within the stand and their purpose is to hold the rocket down during static firing tests. They are not used during actual rocket launchings. The tripods are made of three different grades of stainless steel: type 303 for the screws and couplings, type 420 for the studs, and type 304 for the yokes. The tripods are joined in the center of the stand by two forged blocks of stainless steel designed to connect to the gimbal ring of the first-stage engine by means of a pin.



SWING-AWAY UNITS—The main purpose of the swing-away units is to hold the rocket down and temporarily brace it prior to flight firing. The four units are located on top of the rocket stand and are centered on the cross tubes connecting the stand's four corner pillars. The units are fixed on a simple counterweight and spring system and swing out of the way at the moment of firing.

The retaining devices are made of various grades of carbon steels, with the exception of the main pins which are type 440 stainless steel heat treated to 400 Brinell. This particular grade of stainless was chosen primarily because of its combination of high hardness and corrosion resistance. It is especially important that the pin be hard since it makes moving contact with the engine. It is also important that the pin resist corrosion, since rusting would hinder break away motion.

FINISH ⬇	SIGNIFICANT PROPERTIES	APPROXIMATE COST (materials only)
Varnish	Good hardness and toughness combined with good resistance to heat, water, acids, alkalis and alcohol. Good polishing and sanding properties. Fair initial film color; tends to yellow and possesses poor color stability in comparison to other wood finishes	1.6¢ per sq ft for staining, filling and sealing, and one varnish topcoat
Lacquer	Fast drying properties reduce dirt pick-up and sagging and permit quicker processing. Good color stability and abrasion resistance. Reasonable resistance to dilute alcohol, weak acids, soap, hot and cold water and hot objects. Poor shrinkage properties. Multi-coat application required to obtain sufficient film depth, and richness and clarity of finished wood. Easily patched and repaired	3.1¢ per sq ft for staining, filling and sealing, and two lacquer topcoats
Low Bake Enamel	Comparable to lacquer in appearance, toughness and mar resistance. Provides better resistance to alcohol, perfume, grease, solvents, hot water, humidity, printing and fading. Quite resistant to lighted cigarettes and matches. Difficult to patch because of insoluble nature of film	2.25¢ per sq ft for staining, filling and sealing, and one topcoat
Polyester	Excellent appearance with better gloss and clarity than average lacquer. Excellent resistance to burning, hot water, chemicals, abrasion, cold checking and aging	2.4¢ per sq ft for polyester finish alone. Staining, filling and sealing costs vary with application and with materials selected
Melamine Resin Laminate (high pressure)	Exceptional hardness and resistance to abrasion, wear and heat. Excellent color, color stability and appearance	34-40¢ per sq ft for 1/16-in. laminate alone. Does not include cost of backing board and gluing and assembly operations
Other Laminates (low pressure)	Properties generally same as melamine resin laminates. Excellent hardness, adhesion and color fastness, and resistance to heat, cold checking, abrasion, water and various chemicals. Can be laminated to low density surfaces with low pressure	6.5-10.1¢ per sq ft for transparent finish, plus 7.0-9.5¢ per sq ft for decorative print paper if required. Does not include cost of board backing or laminating process

This table compares the principal

Finishes for Wood

Here is an up-to-date summary of the various types of clear, opaque and laminated finishes that can be used to decorate and protect wood products.

by Albert J. Kirsch, *Plastics & Resins Div., American Cyanamid Co.*

■ Finishes for wood surfaces are designed to perform two essential functions—decoration and protection. Of these two functions, decorative appeal is probably the most important at the time a product is purchased, and it is usually only when the product is in actual use that the protective function becomes paramount.

In addition to its decorative appeal a wood finish must be expected to protect surfaces against marring and discoloration; must be resistant to water, alcohol, perfume, burns, soiling and fading; and must be readily dusted and cleaned. It should also accommodate itself to dimensional changes and not shrink or check. Naturally, no one finish can perform all of these functions to perfection. Some finishes, however, do provide better all around performance than others. The purpose of this article is to describe the various types of wood finishes that are available and what they can and cannot do.

Varnishes

Properties

Varnishes are noted for a desirable combination of properties including: hardness, toughness, good polishing and sanding properties, and good resistance to heat, water, acids, alkalis and alcohol. Because of their good re-

sistance to alcohol, varnishes are still a popular finish for bars. They only rate fair in initial film color, and because of their tendency to yellow they are poor in color stability when compared with other wood finishes.

In general, a high oil content varnish (commonly called a long oil length varnish) possesses excellent flexibility and exterior durability, but dries very slowly. Faster drying varnishes with better hardness and resistance to alcohol and chemicals are obtained with a low oil content.

Though a wood varnish may dry within 3 to 4 hr, it may actually take several days for the finish to develop its full hardness. Varnishes harden by gradual oxidation and polymerization produced by driers present in the formulation. Sanding and polishing operations must usually be delayed for about three days until the coating is sufficiently tough and hard. The short oil length varnishes generally have better rubbing properties and may be formulated as low as 8 gal (i.e., 8 gal of oil per 100 lb of resin) to obtain these properties. However, formulations with an oil length in the range of 8 to 15 gal are relatively brittle and may adhere poorly and check on aging.

Application

One of the principal economy features of varnishes is that they may be thinned with low cost solvents and sprayed at 45 to 50% solids to produce a one-coat finish with good depth. Because of their tendency to discolor, check and lose adhesion, most varnishes are generally used on low cost types of wood products.

It is possible when using a varnish to omit such steps as staining, filling and toning which develop the natural beauty of wood grains, as well as to omit rubbing and polishing of the finish coat. However, to obtain a durable and presentable finish, it is usually necessary at least to stain and seal the wood and sand the sealer before applying the final varnish coating. The sealer coat may be shellac, or the varnish itself to which zinc stearate has been added to promote sanding. Also, the final varnish coating may be treated with flattening agents to produce a soft, low-sheen film which does not have to be rubbed or polished.

Cost

Calculation of accurate cost figures for varnish finishes, as well as other wood finishes, is quite difficult considering the multiplicity of factors involved in materials costs, labor costs and profit margins. However, the following figures should serve as a rough guide.

Satisfactory varnish sealers and varnishes can be purchased at $1.50 to 1.75 per gal. Assuming a coverage of 400 sq ft per gal, total cost of one coat each of sealer and varnish topcoat is about 0.8¢ per sq ft. It has been estimated that staining adds another 0.3¢ per sq ft. Another 0.5¢ per sq ft should be added when the wood has large pores and filling is required for improved appearance. Thus, total cost of the varnish system is roughly 1.6¢ per sq ft.

Lacquers

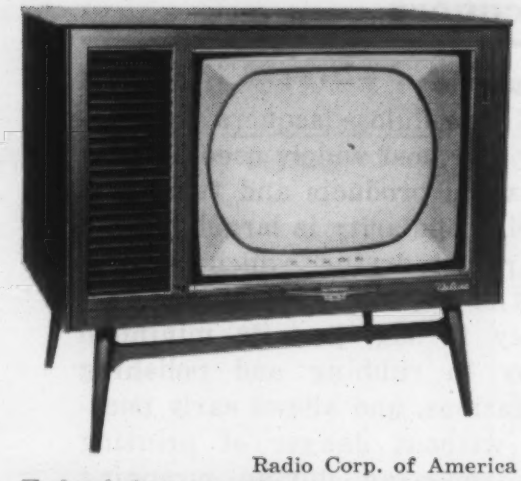
Properties

Nitrocellulose lacquers are probably the most widely used finishes for wood products and furniture. Their popularity is largely due to their fast drying, which contributes to less dirt pick-up and tendency to sag, permits minimum delay in rubbing and polishing operations, and allows early packing without danger of printing (i.e., marring during wrapping and packing). Lacquers, readily applied by spraying, are well adapted for high production.

Lacquer coatings are pale in

School desk *top is made from high pressure plastics laminate because of the material's ability to resist hard usage.*

Fiberesin Plastics Co.



Radio Corp. of America

***Television receivers** such as this color console model are commonly lacquer-coated because of the coating's attractive sheen, protective qualities, and ease and adaptability to quick and easy processing.*

color and possess good color stability. They have reasonable resistance to dilute alcohol, weak acids, soap, hot and cold water and hot objects. They also have good abrasion resistance and wear well. A further advantage is that they can be readily patched or repaired.

Perhaps the most serious disadvantage of lacquers is shrinkage. Films that have been finished to a mirror smooth appearance may appear to sink down into the wood after aging. This tendency can be controlled to some extent by careful formulation, proper rubbing materials and procedures, and the use of adequate drying periods.

A further disadvantage of lacquers is that since they have a high viscosity and low solids content, they must usually be applied in more than one coat to obtain sufficient film depth and sufficient richness and clarity of the finished wood. Multi-coat application, of course, increases the cost of the finishing operation.

Formulation and application

As with varnishes, wood is usually sealed before a lacquer is applied. Sealers are applied over a stain and filler on open grain woods, or over a stain alone on close grain woods where fillers are not necessary. The function of the sealer is to seal the pores in the wood, to seal the stain and the filler, and to prevent the penetration of the lacquer topcoats. A sealer is usually applied by spraying a thin film of 0.3 mil, with 0.1 mil remaining after sanding. Sealers can be formulated from nitrocellulose, alkyds, zinc stearate and hard resins. However, sealers containing high amounts of stearate and/or hard resin possess poor resistance to cold checking.

Shading lacquers can be used over the sealer before the lacquer topcoats are applied. These lacquer stains, also known as toners, have a low solids content and serve to highlight the color of the finish.

Modifying resins and plasticizers are essential ingredients of lacquers since nitrocellulose used alone produces a rather hard, brittle film which has poor adhesion. A typical inexpensive wood lacquer formulation consists of (parts by weight given in parentheses): ½-sec nitrocellulose (100), maleic resin (150), dibutyl phthalate (10) and blown castor oil (40). The maleic resin, or hard resin, serves to increase solids content, gloss and sandability, but tends to lower resistance to cold checking (i.e., cracking on alternate exposure to high and low temperatures). The phthalate and oil plasticizers migrate and do not become a permanent part of the film; the phthalate, being volatile, eventually leaves the film entirely. The above lacquer may be rubbed and polished to a brilliant gloss, but does not have too much merit outside of its low cost.

A much better quality wood lacquer formulation consists of ½-sec nitrocellulose (100), alkyd resin (70), maleic resin (30), dibutyl phthalate (15) and blown castor oil (5). This lacquer rubs and polishes easily and has satisfactory resistance to printing and cold checking.

Rezyl Resin 50-5 is a specialty alkyd developed specifically for high quality furniture lacquers such as the above. The resin is unique in that high percentages may be used with nitrocellulose without impairing drying, rubbing and sanding properties, or limiting packaging schedules. It also allows the use of lower viscosity grades of nitrocellulose, and eliminates the need for chemical and oil plasticizers while imparting permanent flexibility and toughness.

Generally two, and sometimes three, lacquer topcoats are required to obtain sufficient film depth or fullness. Rubbing and polishing are performed 12 to 16 hr after the final topcoat has dried. Typical operations include sanding with sandpaper and mineral spirits, rubbing with pumice stone or steel wool, and final polishing with very fine abrasives. For best cold check resistance, total film thickness after sanding and rubbing should be no more than 3 mils.

Cost

Assuming a moderately priced lacquer with a 24% nonvolatile content sells for $1.70 to 2.20 per gal, the following rough cost estimate (¢ per sq ft) can be made:

Staining	0.25
Filling	0.75
Sealing	0.50
First topcoat (250 sq ft per gal)	0.80
Second topcoat	0.80
Total	3.10

Hot spray lacquers (applied at 120 to 180 F), formulated with high viscosity nitrocellulose and slower lacquer solvents, generally cost somewhat more than cold spray lacquers. The use of hot spray lacquers can often be justified, however, on the basis of their higher solids content and consequent savings in solvents, constant spray viscosity, decreased tendency to sag, better film flow with fewer flaws, and virtual elimination of humidity blushing. Theoretically, hot spray lacquers should grow in popularity because they provide better coverage with fewer coats. However, economies are realized only when two coats of hot spray lacquer replace three coats of cold spray lacquer, or where a single coat replaces two. In the latter case the single coat must be perfect since there is no final coat to take care of skips or "holidays."

Low bake finishes

Properties

Low bake finishes, or heat converting varnishes as they are sometimes called, are comparable to conventional lacquers in their appearance, adhesion, toughness and resistance to marring. They provide much better resistance to alcohol, perfume, grease, solvents, hot water, humidity, and printing and fading, and are quite resistant to burning from lighted cigarettes and matches.

Low bake finishes do not quite attain the film depth or fullness of lacquers. In contrast to lacquers, they are quite difficult to patch because of the insoluble nature of the cured film. Despite their excellent initial cold check resistance, some low bake finishes are prone to shrinking and checking after short periods. However, many of the newer finishes are capable of providing less shrinkage and better film fullness and cold check resistance.

Formulation and application

Low bake finishes usually consist of a combination of alkyd and urea formaldehyde resins, plus an acid catalyst or accelerator. Small amounts of hard resin may also be added to improve rubbing and polishing properties, and even to accelerate curing.

Formulations usually contain 40 to 50% nonvolatile solids, and can be sprayed to give smooth films free of orange peel. The finish bakes to a hard film after 1 or 2 hr at 140 F, or overnight at 125 F.

During baking it is advisable to maintain the oven at 30 to 40% RH to avoid excessive moisture changes in the wood, and to protect glued joints. It is also advisable to allow the finish to dry for 30 min before baking to allow for solvent evaporation and avoid blistering. After baking and a 30-min cooling period, the finish can be dull-rubbed or polished to a full brilliant gloss.

Cost

As with lacquers and varnishes, a low bake finish is applied over wood that has been stained, filled and sealed. The sealer may consist of a light coat of the low bake finish cured for 1 hr at 140 F. The low bake finish offers distinct economy in application in that only one coat is required over a sealer, instead of the two or three coats required of a nitrocellulose lacquer. Very fast rubbing schedules can also be maintained, and there is little danger of rubbing through, a danger which is inherent in using a lacquer or varnish.

A good quality low bake finish costs about $2.50 per gal. Coverage is about the same as for a varnish —approximately 350 sq ft per gal —so that a 1-mil coating of the finish costs about 0.75¢ per sq ft. Materials cost of the complete coating system, including staining, filling and sealing costs, is roughly 2.25¢ per sq ft.

Polyester finishes

Properties

Polished polyester finishes are superior to lacquer finishes in many respects. They have excellent appearance, and their gloss and clarity are better than that of the average lacquer. Also, a single coat is sufficient to achieve build, gloss and clarity, whereas a lacquer may require two to three coats.

Resistance of polyester finishes to cigarette burns is outstanding. These finishes will also withstand hot water for 8 hr or more, depending on film thickness. Alcohol resistance is also very good; however, it is possible for bumps to form in the film due to swelling of the underlying wood fibers. In general, the chemical resistance of a polyester finish is superior to that of conventional wood finishes and approaches that of vinyl films.

Cold check resistance of polyester films is excellent, and since there is no shrinkage the film's aging properties are also quite good. However, if the moisture content of the wood is not properly controlled at the time of finishing, the wood may shrink and give the appearance of not being filled properly.

The scratch and abrasion resistance of polyester films is better than that of lacquers. However, when a scratch is produced it is more noticeable on a polyester film than on a lacquer. It is possible for a polyester film to resist impact blows that would mar a lacquer finish and damage the wood substrate. However, since the polyester film is very hard and brittle, severe impact loads over a certain limit can break the film.

Polyester films and lacquers have about equal resistance to discoloration by sunlight. Use of ultraviolet absorbers (0.25% content) in the film has been found very effective in reducing discoloration of the underlying wood.

Formulation and application

Polyester finishes are applicable to all open and close grain woods including mahogany, walnut, fir, pine, birch, maple, etc. Moisture content of the wood should be kept low to avoid shrinkage.

Both water and spirit soluble, non-grain-raising stains are suitable for use under polyester finishes. These stains exhibit excellent bleaching resistance. Oil stains should be avoided because they are quite difficult to wet with polyester.

Conventional oil fillers are compatible with polyester finishes; however, they are not usually used because of their excessive drying time (about a week). Good fillers can be made from polyester and conventional pigments. These fillers can be applied by brush or spray, but must be wiped off immediately before they become too gummy to handle. Filling does not have to be too thorough since the clear polyester topcoat has considerable filling ability in itself.

Application of a sealer or glaze coat under the topcoat is usually unnecessary. If a sealer or glaze coat is necessary for decorative purposes, however, it may consist of the polyester itself. Adhesion between successive polyester coats is usually good but should be checked for each application. Lacquers that do not contain oils or oil modified resins are also suitable for glaze coats. A satisfactory glaze coat has been prepared from

nitrocellulose, dibutyl phthalate and dewaxed shellac.

A typical polyester formulation that has proved quite successful consists of: Laminac polyester resin (4110-4-6), silica flour, styrene, 6% cobalt napthenate, and methyl ethyl ketone peroxide (added immediately before or during spraying). Purpose of the silica flour is to prevent sagging of comparatively thick films (4 to 5 mils) on vertical surfaces and to aid in releasing air entrapped during spraying.

The styrene serves to control spray viscosity. Best results are obtained using an application viscosity of 40 to 50 sec (No. 4 Ford cup). Below 40 sec the tendency to sag increases, and above 50 sec atomization is poor and too much air is entrapped. Since excessive loss of styrene can produce a poor cure, the finish should be applied in one heavy pass.

Methyl ethyl ketone peroxide and cobalt napthenate are the catalyst and accelerator which effect a cure. Cure occurs in two stages—formation of a soft gel and then a hardening action. It is mandatory that film temperature remain under 95 F during curing since the polyester does not harden above this temperature when the surface is exposed to air. After the film has gelled it will cure to a dull hard surface. Sanding can be performed several hours after application, but should preferably be done after the finish has cured overnight at room temperature. To speed up the finishing schedule, and also to drive off catalyst odor, the film can be force dried 15 to 30 min at 150 F.

Polyester films are easily sanded and polished and are not liable to scorch when buffed mechanically. A mineral spirit lubricant is usually used with the sandpaper. Since the polyester film is hard and not thermoplastic, the abrasive will dull rapidly. The polyester cuts faster than lacquer, and the cuts may be sharper and a little harder to remove.

After sanding, regular furniture buffing compounds can be used at buffing speeds that would scorch a lacquer. However, films should not be allowed to get so hot as to cause gassing in the wood substrate. It is possible to keep the total finishing cycle—from raw wood to polished surface—under 2 hr.

Cost

For a given thickness, a polyester finish generally costs less than a lacquer finish. The lower cost is attributable to the fact that formulations contain 100% solids, as compared to 20 to 25% solids for lacquers, and that only 15 to 20% of the polyester formulation is lost by evaporation, compared to 40 to 50% for lacquers.

One gallon of a polyester wood finish costs approximately $6. Assuming a coverage of 250 sq ft per gal for a thickness of 5 mils, the coating costs roughly 2.4¢ per sq ft. This figure does not include staining, filling and sealing costs, which vary with the type of application and the materials selected. Total labor time, including all operations from filling to polishing, is estimated at 7 min per sq ft.

New Developments

In addition to the polyester and laminating finishes described above, several other finishes for wood surfaces have recently been developed. Use of these finishes is somewhat limited to date; however, they do hold considerable promise for future applications.

Catalyzed epoxy finishes that are formulated from Epon 1001, plus ethylene diamine or Versamid polyamide resins, are hard and glossy, have outstanding resistance to strong alkalis, and have good resistance to alcohol, solvents, boiling water and steam. These finishes dry tack-free in about 2 hr, have excellent adhesion, and possess exceptional flexibility and impact resistance. Their disadvantages include a yellowish color and relatively high cost.

Urethane coatings possess exceptional resistance to chemicals, scratching and abrasion, are quite tough, and have a high gloss. Since the coatings are affected by very small amounts of moisture in the air, films have to be cured immediately after application by low temperature baking. The coatings are more expensive than epoxy finishes and have poor color retention.

Polyester finished hardboards are supplied ready to use. These prefinished boards are relatively inexpensive and are available in clear and decorative finishes. The clear polyester resin is applied by roller, with perhaps an additional spray coat, and is cured under a cover sheet. Decorative finishes are produced by placing a print sheet of wood grain design over the hardboard before the polyester is applied. Hardboards thus decorated cost about 30¢ per sq ft.

Impregnated and cured polyester papers are also available for finishing purposes. These papers are available in decorative patterns and are applied directly to wood surfaces with suitable adhesives.

Vinyl films, applied by similar means, are also available for finishing and decorating plywood. These films are pressure sensitive and can be applied to the wood substrate with very little pressure and at room temperature. Materials cost is about 3.5 to 4.0¢ per sq ft.

Melamine resin laminates

Properties

In addition to the conventional wood finishes that are applied in liquid form, melamine resin laminates also provide a useful method for finishing comparatively large flat surfaces. These laminates are exceptionally hard and resistant to scratches and heat, and have excellent wear properties. They also possess excellent color, color

stability and appearance. Some of the well known melamine laminates are Formica, Micarta and Textolite.

Construction and application

Essentially, a melamine resin laminate consists of three parts:

1. The primary structural element consists of a backing core which consists of layers of kraft paper impregnated with a phenolic resin.

2. The next element is a print sheet which supplies the decorative effect and which consists of a printed, highly pigmented, alpha cellulose paper.

3. The last element is an overlay sheet which is used to protect the entire assembly. The printed overlay sheet is impregnated with melamine resin from water-alcohol solutions and dried in hot air or infrared ovens. When dried, the print sheet may contain 45 to 50% resin and the overlay sheet up to 70% resin.

The laminate is formed by pressing the sheets between polished cauls for 15 to 30 min at 275 to 300 F and 1200 psi. The finished laminate is about 1/16 in. thick and can be glued to any desired wood backing.

Cost

A finished 1/16-in. laminate costs about 34 to 40¢ per sq ft. Total cost of a finished assembly includes this cost, plus cost of the backing board, glue and assembly operations.

Laminated finishes

Properties

The principal advantage of laminated finishes is that they can be directly laminated to a wood surface or to composition board. Because of the high pressure required, the melamine resin described above cannot be laminated directly to low density surfaces such as wood; attempts to laminate melamine-treated overlay sheets directly to plywood and composition boards have resulted in surface cracking of the finish and other defects.

Essentially, a laminated finish consists of an overlay paper impregnated with a board surfacing resin (such as Cyzac 2352) which can be laminated directly to wood surfaces at low pressures. In addition to being transparent and colorless this finish possesses all of the surface characteristics of a high pressure melamine laminate. It does not require rubbing and polishing, and because of its transparency it allows the natural beauty of the wood grain to be seen. The finish can be applied over both close and open grain woods that have been stained and filled in the conventional manner.

Excellent results have been obtained in surfacing mahogany, walnut and birch veneers. For example, a laminated finish on 3/4-in. veneer-faced plywood, has shown outstanding hardness, adhesion, and resistance to marring and cold checking. When subjected to a color fastness test (ASTM D620-45T), this finish showed only a very slight visible change, whereas a typical low bake finish yellowed considerably. The finish also withstood cigarette burning for over 10 min; the low bake finish failed after 7 min.

In addition, laminated finishes have shown no crazing after exposure to a temperature of 220 F for 16 hr, and have passed various NEMA (National Electrical Manufacturers Assn.) tests for resistance to high temperatures. They have also resisted deterioration by such liquids as cold and boiling water, 2B alcohol, 5% sodium hydroxide, 10% citric acid, 5% ammonia, 5% sodium phosphate, 2.5% detergent solution, acetone and washable ink.

Construction and application

Cyzac 2352 board surfacing resin is supplied at a 55% nonvolatile content in a solution of ethyl alcohol and ethyl cellosolve solvent. The overlay paper is treated to contain 73% of this resin. Although opaque in appearance, the paper becomes transparent when laminated under heat and pressure. During laminating, the overlay paper is placed on the core material and the assembly is then pressed between the press or caul plates of a low pressure laminating or plywood press. Curing is accomplished in 10 to 15 min at 300 F and 250 psi.

For best results, the laminated finish should be applied on a smooth surface—in the case of open grain veneers, preferably one that has been sanded and/or filled. However, the laminated finish has been applied to unfilled woods and produced surfaces free from defects. Apparently, the quantity of resin and its flow in the overlay sheet during the laminating operation is enough to fill fairly large voids. Since the flow of resin in the overlay paper may be controlled, the proper flow can be adjusted for open grain veneers or for close grain woods.

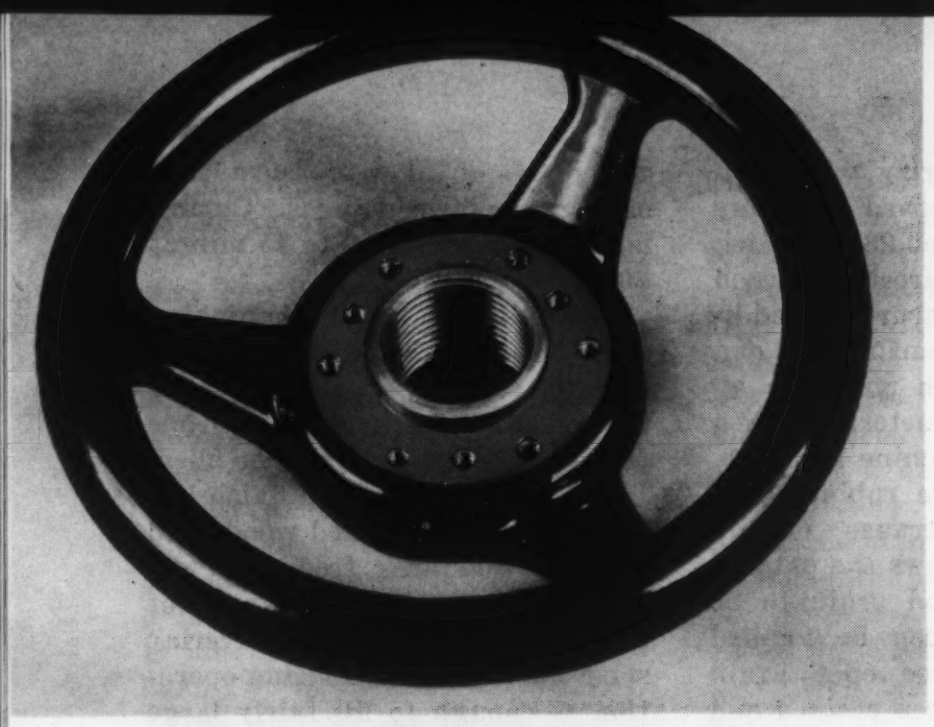
Three types of fillers have been successfully used under these laminated finishes. The fillers (clear or pigmented) are based on raw linseed oil, a long oil alkyd or the board surfacing resin itself. For best results the filling operation should be followed by a 10- to 15-min air drying period and force drying for 1 hr at 140 F.

Use of board surfacing resins is not limited to clear finishes. Finishes whose appearance is similar to decorative melamine resin laminates can be obtained (at the comparatively low pressure of 250 psi) by using a print grade laminating paper in conjunction with Cyzac 2247 resin. The overlay paper (containing 73% resin) together with the print paper (containing 40% resin) is applied to the surface in one operation in much the same manner as the melamine laminate.

Cost

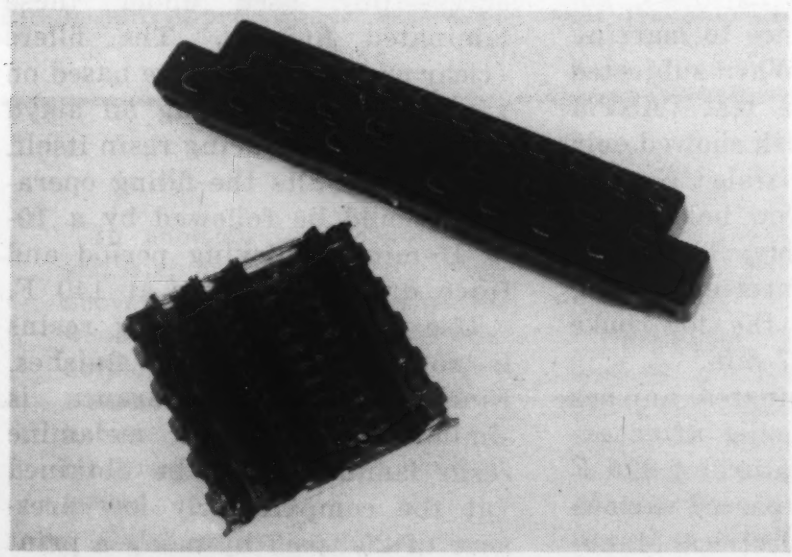
The cost of the transparent overlay paper alone ranges from 6.5 to 10.1¢ per sq ft. Additional cost of the print paper, where a decorative effect is desired, ranges from 7.0 to 9.5¢ per sq ft. Neither of these prices includes the cost of the plywood or composition board backing, nor the cost of the laminating process which is estimated at 5¢ per sq ft.

Based on a paper presented before the Forest Products Research Society and published in the *Forest Products Journal*.

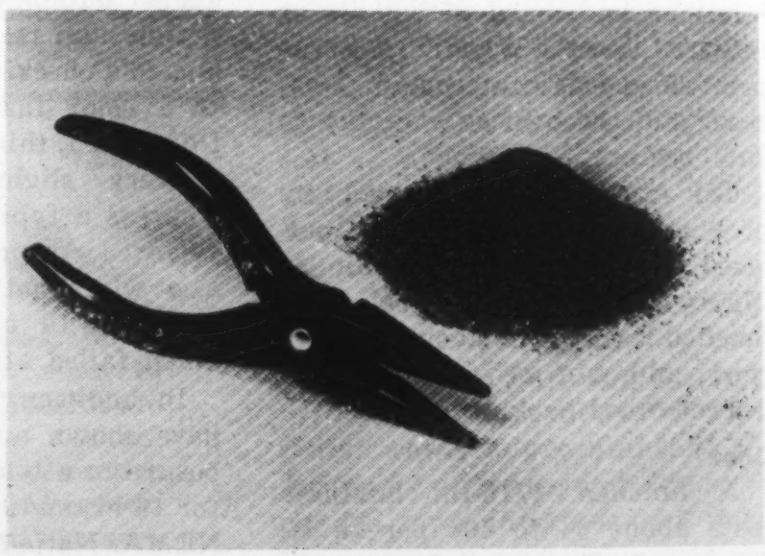


Autoclave control wheel has large molded-in insert. A 2½-lb metal bushing insert was molded into this rubber phenolic wheel without cracking the molding. The material also provides good spoke and rim strength without metal reinforcement, a pleasing appearance, and a feeling of warmth.

Brake motor collector ring uses swaged inserts. Brass collector rings 8½ in. in dia can be swaged onto rubber phenolic parts while still hot. Flexibility of the molding material keeps it from cracking.



Electronic component uses press fitted inserts. Many brass parts have to be press fitted into these electronic data processing components. Close tolerances have to be maintained so that a mating piece with contact pins will position properly. Other materials cracked during press fitting or were too costly. Rubber phenolics provide toughness and flexibility, as well as necessary dielectric characteristics.



Pliers have toughness and dielectric strength. Abuse resistance, good dielectric properties, light weight, attractive appearance and reasonable cost determined the selection of rubber phenolics for these molded "do-it-yourself" pliers.

by E. J. Thomas, *Technical Service Engineer, Chemical Materials Dept., General Electric Co.*

Where to Use

Rubber Phenolic Moldings

These specialized materials are useful where the properties of phenolics are desired but designs call for

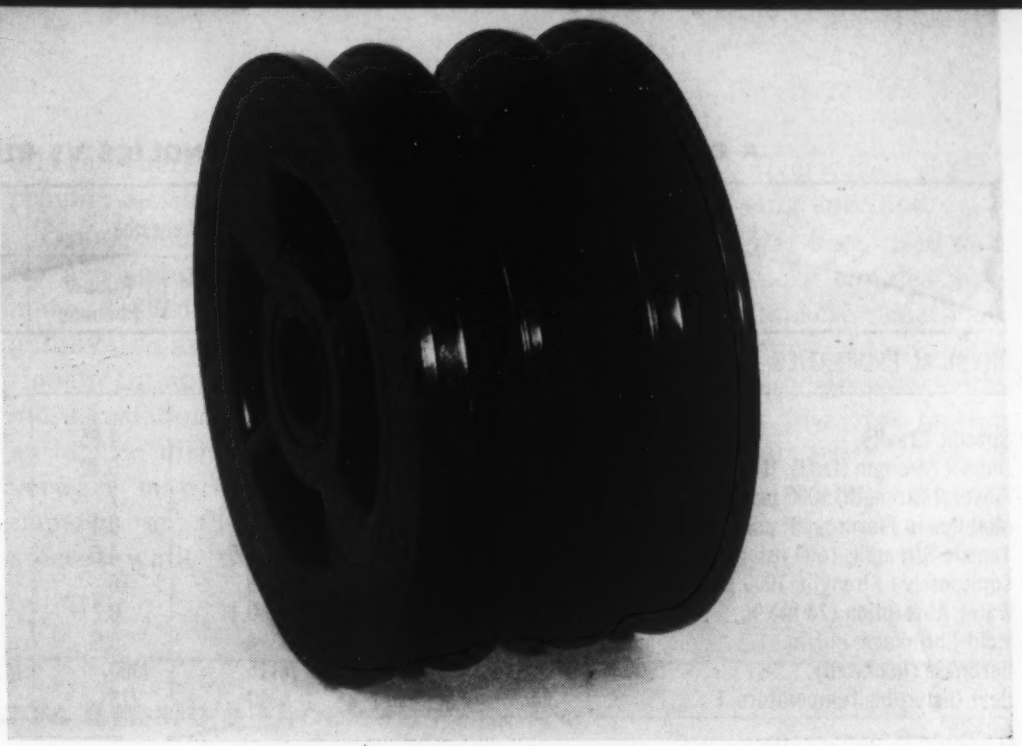
- *Shock or impact loading*
- *Vibration fatigue loading*
- *Large or multiple inserts*

■ Rubber phenolics are hybrid compounds providing most of the conventional properties of phenolics, but with the additional benefit of resilience. They are engineered to provide resistance to shock and impact loading and to absorb vibration without generating fatigue cracks.

Conventional phenolic molding materials provide good mechanical properties, heat resistance, dielectric characteristics, clean surface finish and relatively good impact strength. In some cases, however, lack of resilience has caused failure of conventional phenolics resulting from vibration and subsequent fatigue. Rubber phenolics overcome this problem and in addition provide improvements over other phenolic impact materials in moldability, finishing and machining characteristics, as-molded surface finish, and suitability for incorporating large inserts.

Rubber phenolics are blends of phenol formaldehyde resins and NBR (nitrile rubber). The four types of rubber phenolic molding compounds available differ in the filler materials used; the fillers are woodflour, asbestos, cotton flock and fabric.

The curing system for the materials is double barrelled, designed to trigger the cure of both the phenolic and the rubber simultaneously. Sulfur is used to cure the rubber and hexamethylene tetramine is used to cure the phenolic. Analysis of the cured material discloses no free sulfur.



Drive sheaves feature vibration damping, light weight. The vibration damping ability of rubber phenolics as well as their low weight provide definite advantages when the material is used for molded drive sheaves which must operate at speeds of several thousand revolutions. In addition, the material provides better gripping action for V-belts than steel sheaves, and can result in cost reductions (on larger sheaves) of as much as 85%.

Properties

Properties of the four rubber phenolic molding compounds available are shown in the accompanying table which compares average values for rubber phenolics with those of corresponding grades of conventional phenolic molding compounds.

The rubber phenolics are essentially phenolic materials, retaining a substantial portion of the properties common to conventional phenolics, such as good dielectric properties, relatively high heat distortion temperatures and attractive as-molded finish. The outstanding property of the rubber phenolics is resistance to abuse. Though values obtained from Izod or Charpy tests do show somewhat higher values for rubber phenolics than for conventional phenolics, actual applications for the materials indicate that rubber phenolic moldings are much more resistant to abuse than these figures indicate.

In order to provide an evaluation method giving results that would more closely correspond with those of actual abuse in service, a drop ball test was developed. The test is described and results shown graphically in an accompanying box.

As indicated in these data, each of the rubber phenolic materials is superior in shock resistance to the next higher impact grade of conventional phenolics, and at least equivalent to the second higher impact grade. For example, shock resistance of woodflour-filled rubber phenolic moldings is not only superior to that of woodflour-filled conventional phenolics, but superior to that of flock-filled conventional phenolics and about equivalent to that of fabric-filled conventional phenolics. Similarly, the flock-filled rubber phenolic is superior to the fabric-filled conventional phenolic.

Another important feature of the rubber phenolics is the built-in safety factor from time of crack to complete fracture. Since considerably more energy is required to completely break the molding after the initial crack has occurred, cracked parts can often remain operative until replacements can be obtained.

Design characteristics

When the nature of the materials is understood by the molder so that certain principles of mold design can be followed, rubber phenolics can be molded more easily than impact grades of phenolics, such as those filled with chopped fabrics or cotton flock.

Rubber phenolics are more resilient than conventional phenolics and thus in many cases require less draft for removing parts from the mold. For this same reason, the molder should employ larger knockout pins than those used for conventional phenolics, and they should be placed at more frequent intervals. Cooling forms enable rubber phenolic moldings to be produced to close tolerances.

The materials can be molded in any conventional, well vented mold. Transfer molding provides a ready escape for gas. In compression molding, the positive or semipositive type molds give best

A COMPARISON—CONVENTIONAL PHENOLICS VS RUBBER PHENOLICS[a]

Filler →	Wood Flour		Asbestos		Cotton Flock		Fabric	
	Conventional	Rubber Phenolic	Conventional	Rubber Phenolic	Conventional	Rubber Phenolic	Conventional	Rubber Phenolic
PHYSICAL PROPERTIES								
Specific Gravity	1.37	1.32	1.68	1.65	1.37	1.32	1.38	1.23
Impact Strength (Izod), ft-lb/in.	0.32	0.60	0.34	0.40	0.66	1.00	1.3	2.30
Flexural Strength, 1000 psi	10	7	9.5	7	10	7	10	8
Modulus in Flexure, 10^6 psi	1	0.35	1	0.4	1	0.45	1	0.4
Tensile Strength, 1000 psi	7	4.5	5.5	4.5	6	5	6.5	3.5
Compressive Strength, 1000 psi	25	18	28	16	25	18	25	18
Water Absorption (24 hr),%	0.7	1.4	0.1	0.2	0.7	1.2	0.9	1.4
Mold Shrinkage, mil/in.	7	8.5	4	5.5	5	5.5	3	3.5
Hardness (Rockwell)	M110	M50	M115	M60	M100	M55	M110	M55
Heat Distortion Temperature, F	300	250	340	275	320	250	300	230
ELECTRICAL PROPERTIES								
Dielectric Strength (60 cycles), v/mil								
77 F, Instantaneous	350	300	300	350	325	325	300	250
77 F, Step-by-Step	300	250	200	300	250	224	225	200
212 F, Instantaneous	150	125	120	85	125	75	120	80
212 F, Step-by-Step	90	70	70	60	70	55	46	50
Power Factor (dry)								
60 Cycles	0.12	0.14	0.35	0.15	0.21	0.50	0.40	0.45
1000 Kc	0.05	0.08	0.30	0.10	0.05	0.01	0.06	0.10
Dielectric Constant								
60 Cycles	13.0	9.0	42.0	15.0	9.0	15.0	10.0	15.0
1000 Kc	5.0	5.0	8.0	5.0	5.5	5.0	6.5	5.0
Volume Resistivity, ohm-cm	8×10^{10}	3.75×10^9	7×10^{11}	2.5×10^{11}	2.65×10^{11}	6×10^{11}	8.10^9	1×10^{11}
Insulation Resistance, megohms	2×10^4	5×10^4	1×10^4	2×10^4	1×10^5	6×10^2	3×10^4	7×10^2
CHEMICAL RESISTANCE (% increase in weight)[b]								
Sulfuric Acid (30%)	1.5	2	1.1	0.9	2.6	1.6	3.0	1.8
Sulfuric Acid (3%)	2	3	0.6	0.4	3.9	3.9	4.2	3.9
Sodium Hydroxide (1%)	1.8	12	0.2	0.6	3.5	11	3.5	6
Acetone	0	20	0	25	0	21	0	15.5
Ethyl Acetate	0.5	8	0.1	6.3	0.2	8.3	0.2	5.1
Ethylene Dichloride	0.1	13	0.2	14.1	1.0	13.5	0.1	6.9
Carbon Tetrachloride	-0.01	0.2	0.2	0.5	0.2	0.4	0.3	0.6
Toluene	0	1	0.1	1.1	0.2	1.5	0.1	1.4
Heptane	-0.1	0.01	0.1	0.04	0.4	0.02	0.6	0.09
Sodium Chloride (10%)	0.8	2.3	0.3	0.4	0.7	2.6	0.9	2.8
Distilled Water	1.3	4	0.2	0.5	2.5	4	3	4

[a] Average values.
[b] Based on 2-in. dia disks totally immersed at room temperature for 7 days.

results (for a discussion of these types of molds see MATERIALS IN DESIGN ENGINEERING, Nov '57, p 128).

Inserts—An extremely useful design characteristic of rubber phenolics is their ability to accommodate very large inserts, both those inserted during the molding operation and those inserted after molding. The materials can accommodate these large inserts because they have: 1) higher shrinkage than conventional phenolics, 2) toughness, 3) flexibility, and 4) good thermal shock resistance.

The higher shrinkage of rubber phenolics ensures a firm gripping action on molded-in inserts, yet the toughness of the material eliminates cracking which might be caused by the shrinkage.

As the molded part with the large insert is taken from the mold and allowed to cool, internal stresses are set up which normally play havoc with conventional materials. The flexibility of the rubber phenolics provides a more uniform distribution of stresses around the large insert, ensuring a crack-free, serviceable molding. The degree to which rubber phenolics withstand stresses set up on cooling is indicated by the fact that the materials can withstand a rapid temperature change—from –40 F to 245 F—even when molded around large complex inserts.

Toughness and ability to flex slightly also make rubber phenolics ideally suited to accept inserts applied after molding, as well as pressed or swaged fittings. The materials also retain high speed self-tapping screws, can be drilled and tapped with ease, and have much better machinability than other high impact grades of

phenolics. The machinability of the materials is such that using a woodflour-filled rubber phenolic instead of a woodflour-filled conventional phenolic can lengthen machine tool life six-fold.

Applications

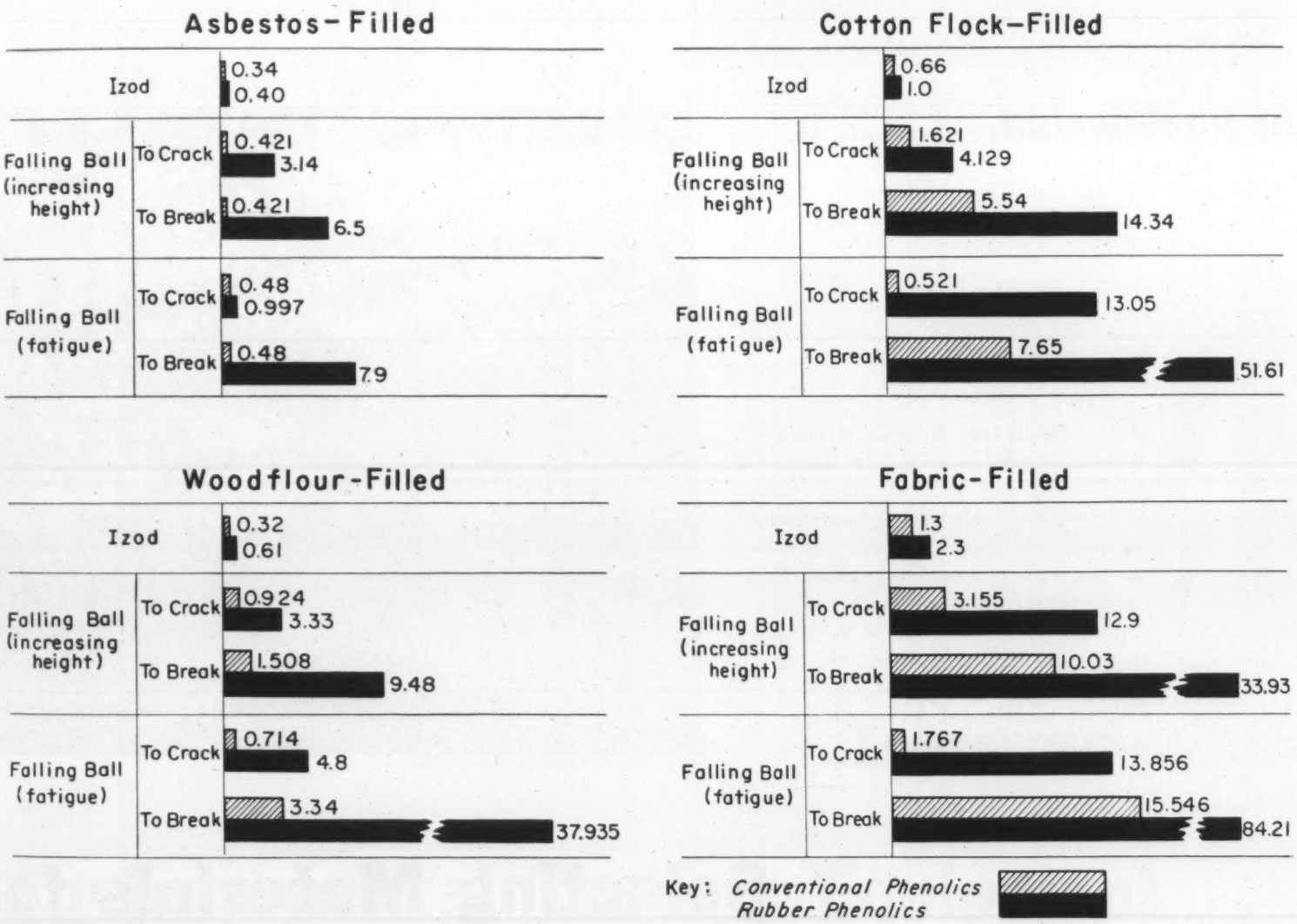
The accompanying case histories indicate the major benefits to be obtained by designing with rubber phenolics. In addition to these applications there are many others where the materials can provide distinct advantages.

Conventional flock-filled phenolics are being used for more and more molded pump impellers in automotive and appliance applications. In applications requiring more resistance to abuse, such as automatic dishwashers where silverware may be dropped on the impeller or the motor may be started while the impeller is in contact with silverware, rubber phenolics are being specified.

Hard rubber has been used successfully for cutlery handles, giving excellent impact resistance, detergent resistance and a variety of colors. The only drawback has been relatively low production rates due to slow cures. Use of rubber phenolics and multiple cavity molds can increase production rates substantially.

Static vs dynamic shock resistance

(rubber phenolics and conventional phenolics; measured in ft-lb)

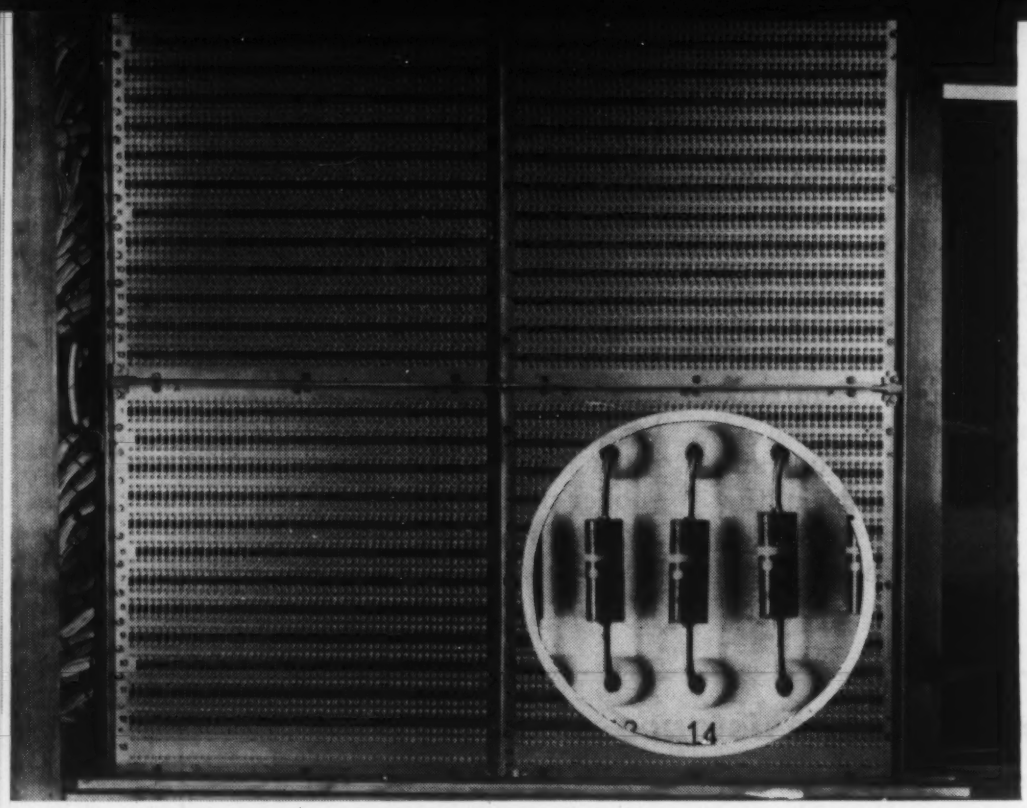


The Drop Ball Test

A box (8 x 1¾ x 1⅛ in. with a 3/32-in. wall) is molded of the material to be tested. The test blow is delivered to the center of the side of the box. A ball is selected of a weight that will crack the test specimen when dropped from not less than 13 nor more than 19 in.

The test is started at a height of 9 in., the height of drop being increased 1 in. with each succeeding drop. The height at which cracking occurs is noted and testing is continued. Height at which breaking occurs is then noted. Total foot-pounds of energy to crack and break are calculated for each specimen. Values are then averaged and the result reported as the energy value for each compound.

To determine fatigue strength of a compound, 75% of the height at which cracking occurs in that compound is used as a base. The ball is dropped repeatedly from this height and the number of blows to crack and break are noted. Total foot-pounds to crack and break are then calculated for each specimen, values are averaged, and the result is reported as the energy value for each compound.



1. Resistor mounting board—Each test chamber has one 36-in. square mounting frame constructed of chromate-treated aluminum. Each frame holds four 18-in. square aluminum terminal boards. On each board there are 1326 electrotinned brass terminals which are insulated from the board by polytetrafluoroethylene inserts. Thus, 663 resistors can be mounted on a board and 2652 resistors on a frame.

The final design

2. Resistor board wiring—Resistors are mounted to the terminals on one side of the board. On the other side of the board, one terminal of each resistor is connected to a common terminal. The opposite terminal of each resistor connects to a lead. These leads are tied together with wax-impregnated nylon cord in groups of 51. There are 50 bundles of cabled wire in each four-board frame.

Selecting Materials for

In testing electrical components you have to be sure that the testing equipment itself withstands the environment —and without affecting the test results. Here is a case history of such a design.

by Curtis Morling and John Bellinger, *Inland Testing Laboratories, Div. Cook Electric Co.*

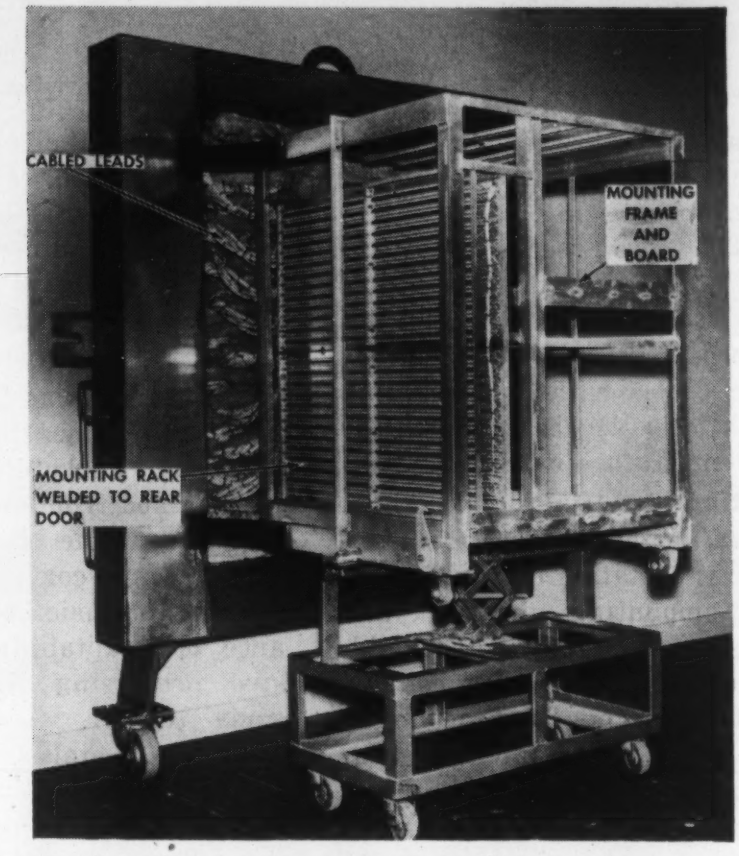
This article is based upon a winning entry in last year's Awards Competition for the Best Use of Materials in Product Design.

■ The reliability test section of Inland Testing Laboratories was recently assigned a program of simultaneously testing over 70,000 resistors under simulated environmental and load cycling conditions. This posed some interesting materials problems that had to be solved.

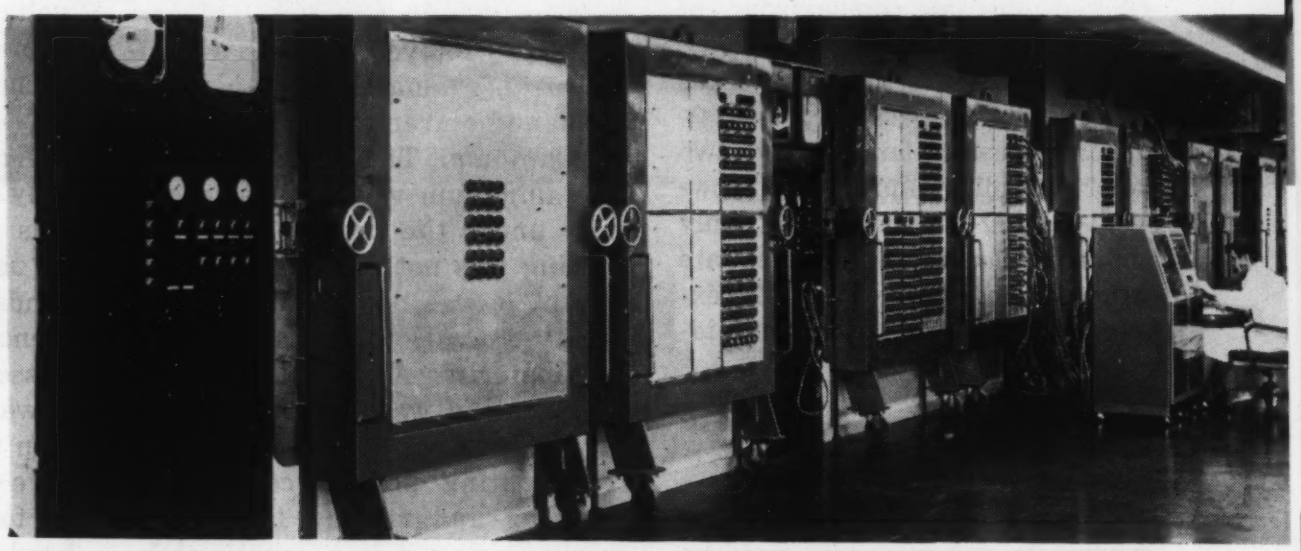
Materials requirements

To conduct a reliable test program, it was important that the

3. Pin receptacle—Each group of 51 leads is soldered to 51 pins of a 52-pin receptacle. The receptacles in which the wires terminate are fitted into panels which fit the front of a door assembly.



4. Door assembly—The mounting boards, frames and associated cables are placed in racks affixed to the back frame of the door assembly. When the door is rolled into position, the mounted components are inside an environmental chamber.



5. Measuring equipment—Automated measuring and recording instruments are connected to the components (by means of the receptacles) and measurements are recorded on punched cards. The system is capable of performing over a quarter of a million measurements in a day.

Environmental Testing Equipment

materials used for the frames, mounting boards, terminals and insulators did not affect test results. In addition, there were several other important factors which had to be considered before materials could be selected:

1. The material used for the mounting boards and frames had to be light enough to permit easy movement during the fabrication.

2. The mounting boards had to be easily drilled for the insertion of a large number of resistors.

3. The mounting frames, insulators and terminals had to maintain dimensional stability during continuous operation in three-week cycles, under exposure to temperatures as low as –67 F and as high as 255 F, with relative humidity as high as 100%.

4. All insulating materials had to maintain an insulation resistance of at least 100,000 megohms under the above conditions.

5. Since components under test had to be permanently mounted on racks which were to be a part of the door assemblies of the environmental test chambers, the door assemblies had to be interchangeable between chambers without disturbing the components or associated cables.

6. Stand-off mounting terminals

had to be able to hold the weight of the mounted resistors without bending or sagging.

7. The cord used to tie the cables together and the cable strips used to support the cables had to bear the weight and strain of the cables without expanding enough to loosen the cables at the high temperature extremes.

Selecting materials

Mounting boards and frames—The first tentative design for resistor mounting boards and frames was oriented toward avoiding the problem of wiring connections to thousands of components. Since printed circuits are much less expensive than conventional wiring and since the laminated plastics on which circuitry could be printed appeared to fulfill some of the requirements of light weight, workability, low cost and availability, it was decided to test several plastics laminates.

The initial testing program was devoted to a comparison of samples of possibly appropriate plastics laminates. The materials tested included glass-epoxy, glass-silicone, glass-melamine, and two paper-phenolic laminates. However, testing indicated that only one of the laminates had adequate insulation resistance under the extremes of temperature and humidity to which the components were to be subjected. Further testing showed that this laminate would not maintain dimensional stability, and the entire printed circuit design was abandoned.

A new design utilizing conventional wiring was then developed. Required dimensional stability, lightness, workability, etc., could be obtained from any of a number of metals. The choice was based on cost and corrosion resistance (either intrinsic corrosion resistance or adaptability to inexpensive processing to achieve the same result). Commercial suppliers of metals were consulted and catalog information was compared, obviating the need for testing. The material finally chosen was a wrought aluminum alloy, heat treated and aged. Specifications and properties are given in Table 1.

As shown in the table, the SAE 281 aluminum alloy selected has relatively high resistance to corrosion. However, this is a comparative evaluation provided by a manufacturer of several types of aluminum. The degree to which the aluminum would resist corrosion under the proposed extreme cycling was not established. As a result, it was decided to coat the aluminum with a corrosion resistant material. A chromate conversion coating was selected because it provided protection at low cost. The coating process consists of washing and rinsing the aluminum, dipping it in a caustic etchant, rinsing again, dipping it in an alkaline-caustic solution, rinsing again, and dipping twice in the chromate conversion (Alodine) solution and then rinsing.

Stand-off terminals and insulators—Once the decision was made to use aluminum for the boards instead of laminated plastics, it became necessary to design stand-off terminals and stand-off insulators. The only decision to be made concerning the stand-off terminals was whether to use silver plated brass or electrotinned brass. Electrotinned brass was selected because the silver was found to undergo migration under the extremes of temperature and load cycling.

For the stand-off insulators, previous experience with tetrafluoroethylene led to the belief that the material would perform satisfactorily. Nevertheless, samples were subjected to the following two tests:

1. Four stand-offs with 1-lb weights attached to their ends were mounted on an aluminum board and placed in an oven at 250 F. After 123 hr the board and stand-offs were removed and the only physical change observed was a very slight sag. While still hot, the board was put into a low temperature chamber (–67 F); after 17 hr the board was removed and no visible change was observed.

2. The weights were removed and tetrafluoroethylene-insulated wire was soldered to the ends of each of the four stand-offs. The stand-offs were then subjected to voltage breakdown at room conditions and in a humidity chamber. Results proved that the material would perform satisfactorily.

Lacing cord and strap—The only materials problem remaining was to determine what material to use for the lacing cord which binds the cabling. Previous experience indicated that nylon cord possessed adequate strength, but it was decided that wax impregnation would afford additional moisture and temperature resistance. To test the wax-impregnated nylon cord, a sample was subjected to a temperature of 250 F for 96 hr. Upon removal, the sample was bent by hand and visually inspected. There was no observable effect on the lacing except that the wax had become soft and pliable. While still hot, the sample was placed in a cold temperature chamber and subjected to a temperature of –67 F for 24 hr. When removed, the sample was again bent; there were no visible effects except that the lacing had become stiff.

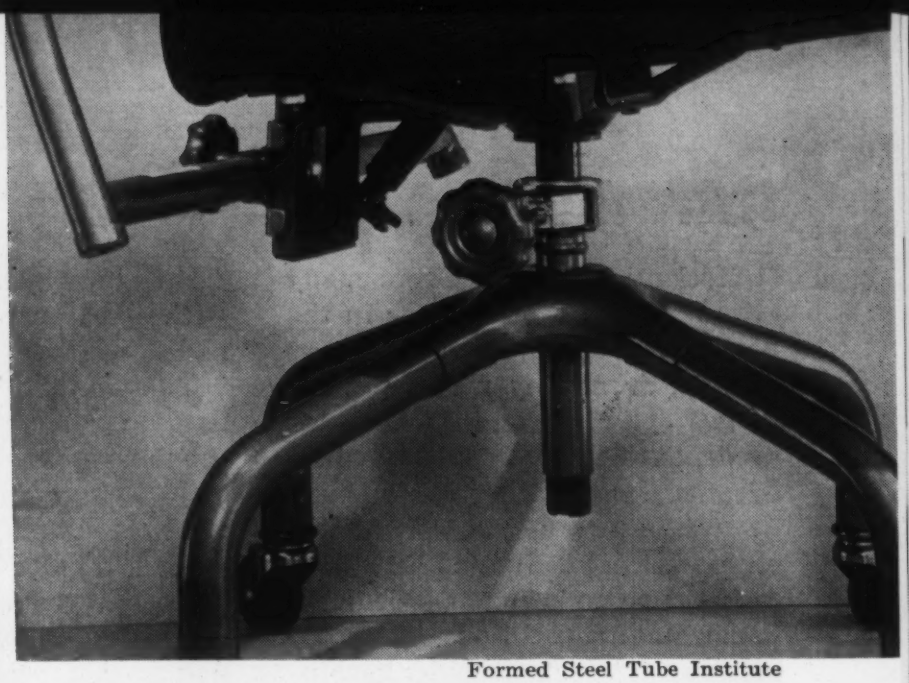
After stabilizing at room temperature for 3 hr, another visual inspection showed only a slight increase in lacing slippage.

PROPERTIES OF SAE 281 ALUMINUM ALLOY[a]

Density, lb/cu in.	0.098
Resistance to Corrosion[b]	Excellent
Workability	Fair to good
Machinability	Good
Brazability	Excellent
Weldability	
Gas	Excellent
Arc	Excellent
Resistance (spot and seam)	Excellent
Tensile Strength, 1000 psi	45
Yield Strength (0.2% offset), 1000 psi	40
Elongation (in 2 in.), %	
1/16 In. Thick (sheet)	12
1/2 In. Dia (round)	17
Compressive Yield Strength, 1000 psi	40
Shear Strength, 1000 psi	30
Fatigue Endurance Limit, 1000 psi	13.5
Hardness, Brinell	95

[a]Heat treated and aged.
[b]Relative to aluminum alloys only.

International Nickel Co., Inc.



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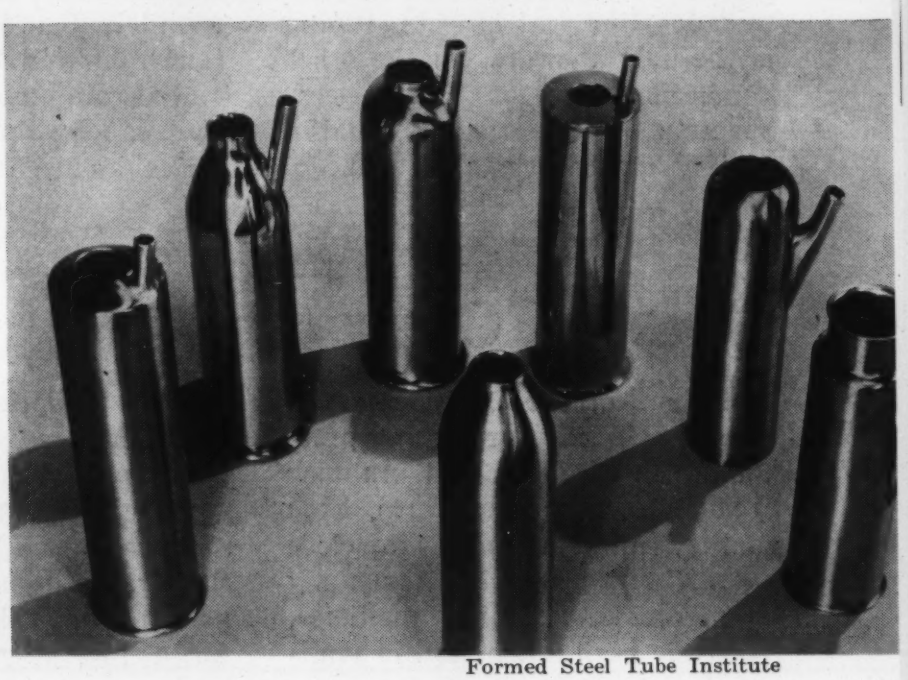

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Some applications *of mechanical tubing include a pure nickel ladder for the hold of a chemical tanker, the steel framework of an office chair, and stainless steel parts for an automatic milking machine.*

Materials
in Design Engineering

Manual No. 144
December 1957

Mechanical Tubing

by Jack C. Merriam, *Associate Editor, Materials in Design Engineering*

Mechanical tubing is a versatile, basic metal form manufactured specifically for further processing into fabricated parts. Its advantages of inherent structural strength, weight saving, and reduction of production time and costs make it attractive to the engineer for the design and production of a wide variety of products. This manual outlines the types and shapes of mechanical tubing that are available, the ways in which it can be worked and fabricated, and some typical applications. It also gives the principal characteristics of these tubing materials:

- *Carbon and Alloy Steels*
- *Stainless Steels*
- *Copper and Copper Alloys*
- *Nickel and Nickel Alloys*
- *Aluminum Alloys*
- *Magnesium Alloys*
- *Titanium*
- *Specialty Alloys*

Introduction

■ Mechanical tubing offers many advantages to the engineer in the design and production of items ranging from tiny watch pinions to gas cylinders and even larger products. Some of the important advantages of tubing are savings in weight, inherent structural strength, and reduction in fabricating time and costs, particularly in machining operations. For some parts, such as relatively long, thin-walled cylindrical objects, tubing is the only answer. On the other hand, there are many uses—e.g., bushings, metal washers, and a variety of cylindrical-shaped objects—in which tubing competes with bar, punchings, machined parts, welded parts and castings.

The word "tubing" is sometimes used to describe several different tubular products, including pipe and casing; however, it refers more specifically to seamless or welded tubular forms which are manufactured to closer size tolerances than pipe. Another distinction is that practically all pipe is round in section, whereas tubing is available in a variety of shapes and also in most metals and alloys that can be formed.

Besides mechanical tubing, there are two other principal types of tubing—pressure and structural. Pressure tubing is used to convey liquids or gases under pressure; it will not be covered in this manual. Structural tubing is used primarily for structural purposes; it also will not be covered specifically here, but in most cases mechanical and structural tubing are one and the same product, and the distinction rests only upon the application. And even here, the distinction is often not clear-cut because many fabricated tubular parts serve simultaneously as structural members.

General Characteristics

Mechanical tubing is manufactured specifically for further processing into fabricated tubular products. It is of uniform, high quality, and produced to close tolerances. In addition, it usually has good machining qualities, relatively high finish, and is available in a wide range of materials, analyses, shapes and sizes.

Materials, types and shapes

The principal materials in which mechanical tubing is produced are carbon, alloy, and stainless steels, copper and copper alloys, aluminum and its alloys, magnesium alloys, titanium, and nickel and nickel alloys. In addition, specialty tubing is made from a number of other, less common materials.

Tubing of most materials is furnished in a number of different conditions or tempers to meet specific forming or service requirements. It is also normally available in at least one or two standard finishes. The finishes, of course, depend upon the material and methods of manufacture. Where required, any one of a variety of special finishes can be had on order. For example, tubing can be obtained with a special inside surface, a special outside surface, or both. For applications such as plated parts or parts requiring exceptionally smooth, uniform surfaces, the tubing can be furnished ground and polished.

Tubing is produced either in seamless or welded form. Seamless tubing, as the name indicates, has no longitudinal seam; however, for a few applications, seamless tubing is joined end to end and therefore has a circumferential seam. Welded tubing is manufactured from flat stock and has a longitudinal seam. Some of the materials mentioned above can be produced only in seamless or only in welded tubing, whereas others can be produced in both forms.

Seamless and welded tubing are alike in many of their characteristics, but differ in others. The choice between the two, therefore, depends upon the requirements of each application. Welded tubing is made with relatively thin walls. Seamless is produced in a larger range of sizes and wall thicknesses, including heavy walls. Since welded tubing is made from flat rolled stock, somewhat closer wall thickness tolerances can be maintained than with seamless. Welded tubing is available in only those materials and grades of material that are weldable.

In mechanical properties, as-welded tube is about equal to the flat stock from which it is formed. Its properties are generally lower than those of cold drawn seamless tubing because of the improvement in properties resulting from cold work. However, drawn welded tubing compares with seamless in its properties. Both welded and seamless tube are closely comparable in their forming characteristics. Where performance requirements can be met, welding tubing (as welded), in general, will be somewhat more economical than seamless.

One of the big advantages of mechanical tubing is that it can be obtained in a wide variety of sizes and shapes. In many cases, by proper design of the part and careful selection of the tubing, machining and other shaping operations can be cut to a minimum.

The most common and widely used shape of tubing is the round section. Many other cross sections are available, however, to meet specific problems. Square and rectangular sections are produced as standard shapes by most tube producers and are available in a wide range of sizes. In addition to these, many producers manufacture other shapes which they have available in a regular range of

sizes. The following are some of the special shapes that can be produced on order: embossed; fluted outside, plain inside; fluted; hexagon; lip; octagon; pinion (longitudinal serrations on outside); polygonal outside, round inside; reeded outside, plain inside; reeded; roped; rope-fluted; rope-reeded; round outside, polygonal inside; and twisted.

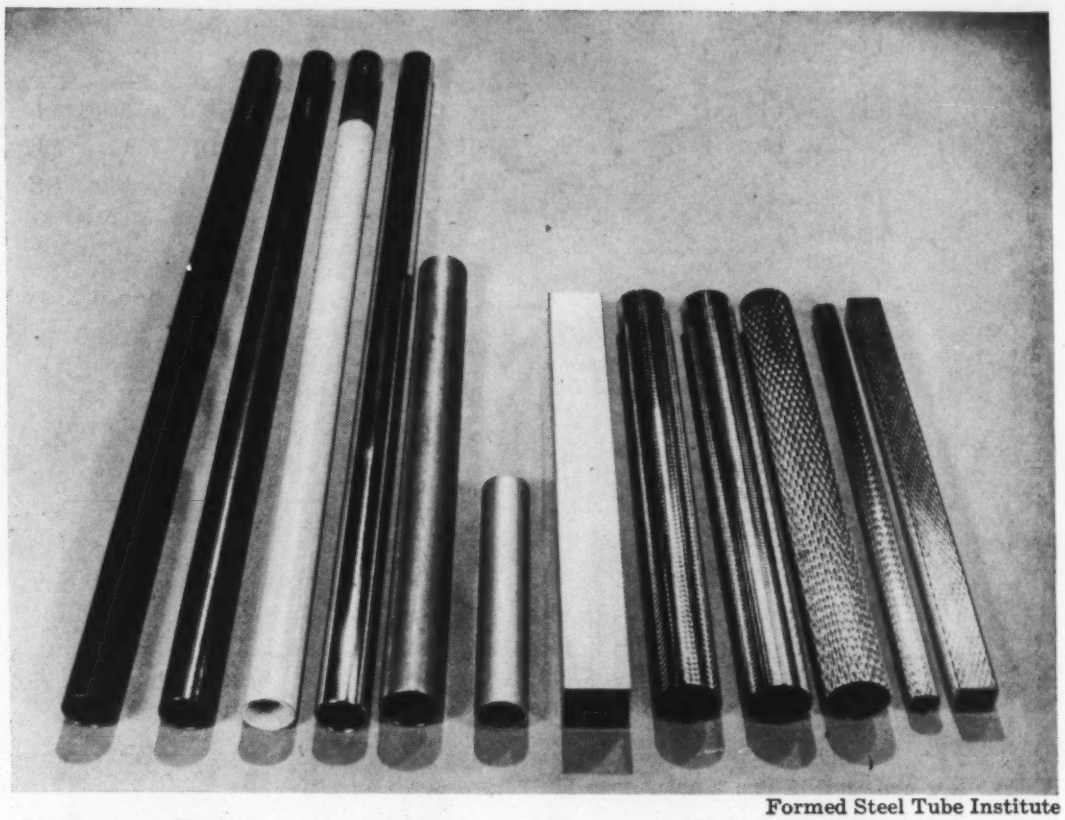
Tolerances

As pointed out before, a distinguishing characteristic of mechanical tubing is the close tolerances to which it is produced. In extremely small sizes for example, tolerances on the cross-sectional dimensions can often be held to ±0.002 in. These fine tolerances facilitate fabrication in a number of ways and cut production costs.

Round tubing has three cross-sectional dimensions which must be considered in ordering and fabricating. They are outside diameter (o.d.), inside diameter (i.d.), and wall thickness or gage. In seamless and drawn welded tubing each of the dimensions may vary independently; therefore it is important to have a knowledge of the tolerances to which the tubing is manufactured. The o.d. tolerance (and i.d., when specified) is commonly given as a definite permissible variation in thousandths of an inch. Wall tolerance, however, is often given as a percentage of the specified wall.

Because of manufacturing limitations, drawn and extruded tubing is not always truly concentric. The distance off-center between the o.d. and i.d. is termed eccentricity and is reflected in variations in the wall thickness. It has no effect on the o.d. or i.d. The variation in wall thickness is of particular importance when the tubing is to be machined. Enough stock must be allowed not only for the tool cut on both surfaces, but also for the maximum eccentricity which is reflected in the wall thickness.

Tubing also usually has a certain amount of ovality, as measured by the difference between the maximum and minimum diameters of any one section of the tube. Ovality of seamless tubing depends upon several things, including temper, wall thickness and straightness.



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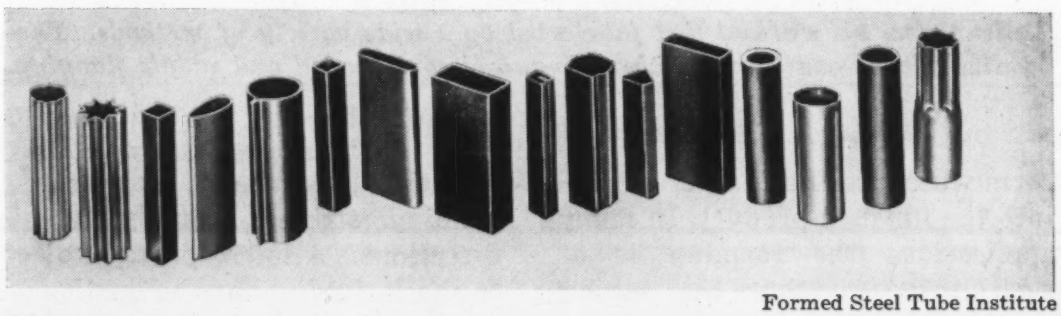
Variety of finishes *obtainable on carbon steel tubing is indicated by these rolled, square and rectangle shapes.*



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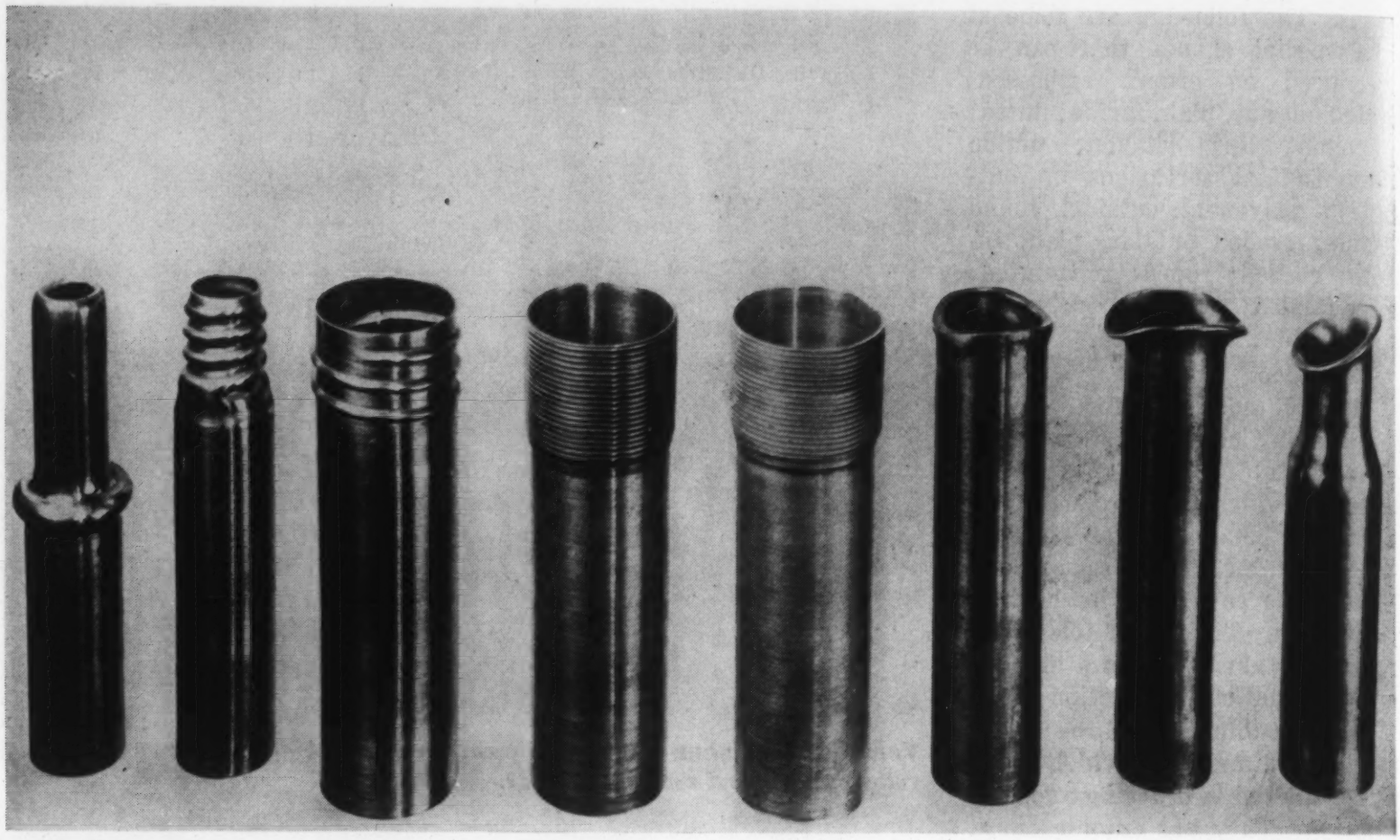
Shapes *in which mechanical tubing can be produced are almost unlimited. An idea of the range can be obtained from this illustration of welded carbon, alloy and stainless steel tubing.*

Applications

Tubing offers a number of inherent advantages, not found in other metal forms, that suit it to a wide range of applications. Most parts of a generally cylindrical or ring-like shape can usually be made more efficiently from tubing than from bar stock, because when tubing is used such parts are already partly fabricated.

Tubing may cost more than bar stock, but savings in processing often offset additional materials cost. Thus, drilling operations can be eliminated, and drills replaced by simple, less expensive boring tools. Boring can be done faster than drilling; chucking pressures are reduced. There is also less tool wear and fewer tool changes. In many cases the use of tubing makes available additional tooling positions. With multiple spindle automatic screw machines, many parts can be machined two or more per cycle instead of one per cycle.

The applications of tubing are extended by its ability to be worked and fabricated into parts by many methods which will be described in the next section of this manual. Because tubing is adaptable to further fabrication, it actually serves as a semifinished



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Tubing can be worked *and fabricated by a wide variety of methods. These examples show the results of reducing, beading, flared-end turning, threading, and cold headed and saddle flanging.*

form which can be further shaped into the finished product. In many applications the forming is of such a nature that the tubing practically loses its identity as such. A few typical applications of fabricated tubular parts are: bearing races, bushings, lathe spindles, cylinders, containers, hypodermic needles, axle housings, sporting goods, housing assemblies, and gun parts such as magazine tubes, magazine clips and receiver sections.

Outstanding applications of mechanical tubing are shown and described in more detail in the accompanying illustrations.

In addition to the types of applications mentioned above, tubing is frequently used to serve as a load carrying member or part, because it has a number of structural advantages over other metal forms. For a given weight, a tube provides the best section under practically all load conditions. Where a part must withstand equal loading in any direction, a tube offers the best cross section. Tubing has superior bending qualities, because it can resist bending stresses equally in all directions. Also, in parts subject to shock, tubing has the quality of tending to absorb and localize the shock. Under dynamic loading, a tubular section provides higher rigidity, and has a higher frequency and smaller amplitude of vibration. Finally, in torsion, round tubing provides the best material distribution, and for a given weight can withstand more load than other sections.

A few typical applications that make use of these structural advantages are: automotive transmission shafts, drive shafts, spline shafts, aircraft struts and other airplane structural members, furniture, and framework for buses and trucks.

Forming methods

One of the reasons why tubing has such a wide range of uses is its adaptability to a variety of forming methods. The most commonly used methods are briefly described below, and the shapes into which tubes can be formed are discussed.

Bending—This is the most common method of forming tube. In bending operations the outside of the bend is stretched, and the inside is compressed, so that buckles or wrinkles tend to form on the inside bend. Therefore, the extent to which tubing of any given material can be bent is limited, depending upon the size, gage and condition of the metal. The minimum radii to which a tube of a given material can be bent without distortion depends on wall thickness and tube diameter. For light gage work, a mandrel must be used to prevent buckles.

There are two methods of bending tube. One is bending without a mandrel, often called press bending; the other is bending with a mandrel. Bending without a mandrel is the cheaper of the two. The tools are inexpensive and can be used over a wide range of angles. Also, the operation is rapid. With some exceptions press bends are used on steel tube when the o.d. of the tube does not exceed 2½ in., and the angle of the bend does not exceed 90 deg; when

the o.d. exceeds 2½ in., the angle of bend must not be greater than 75 deg.

A better grade of bend is usually obtained by using a mandrel. However, the tools are more expensive and the operation is slower. The equipment consists of a bending die and mandrel holder, with the necessary jaws and clamp to grip the tube while being bent. This method is used when the metal must be kept smooth, or where a minimum reduction in diameter in the vertical plane is desired.

Swaging—By swaging, the diameter of a tube can be reduced over part or all of its length. The reduction is accomplished either hot or cold, depending on the metal, by a series of blows with a rotary swaging machine, power hammer or hydraulic press. If it is done cold, the swaged tube often needs a subsequent annealing to relieve the cold work stresses.

The wall thickness of the swaged portion will usually be thicker than that of the original tube. No definite rules for the amount of increase can be given; however, in general, a given percentage reduction in diameter will give approximately the same percentage increase in wall thickness.

Tapering of tube is also done by a swaging process. Tapering is more expensive since it requires accurate dies that will be in line and properly matched during the swaging operation.

Spinning—Spinning is a popular and versatile method for shaping tube. One method involves rotating the tube at high speed with a forging tool or roll held against it, shaping it to the desired form. Another method is to hold the tube stationary and rotate the tool. Spinning can be done hot or cold. When done cold, the heat generated by friction between the tube and tool facilitates the forming operation. In hot spinning, the portion of the tube to be spun is heated to the forming temperature and then the forming tool is forced against the work. Hot spinning is somewhat faster than cold spinning.

The chuck is usually made of hardwood, but metal may be used if a number of parts are to be made.

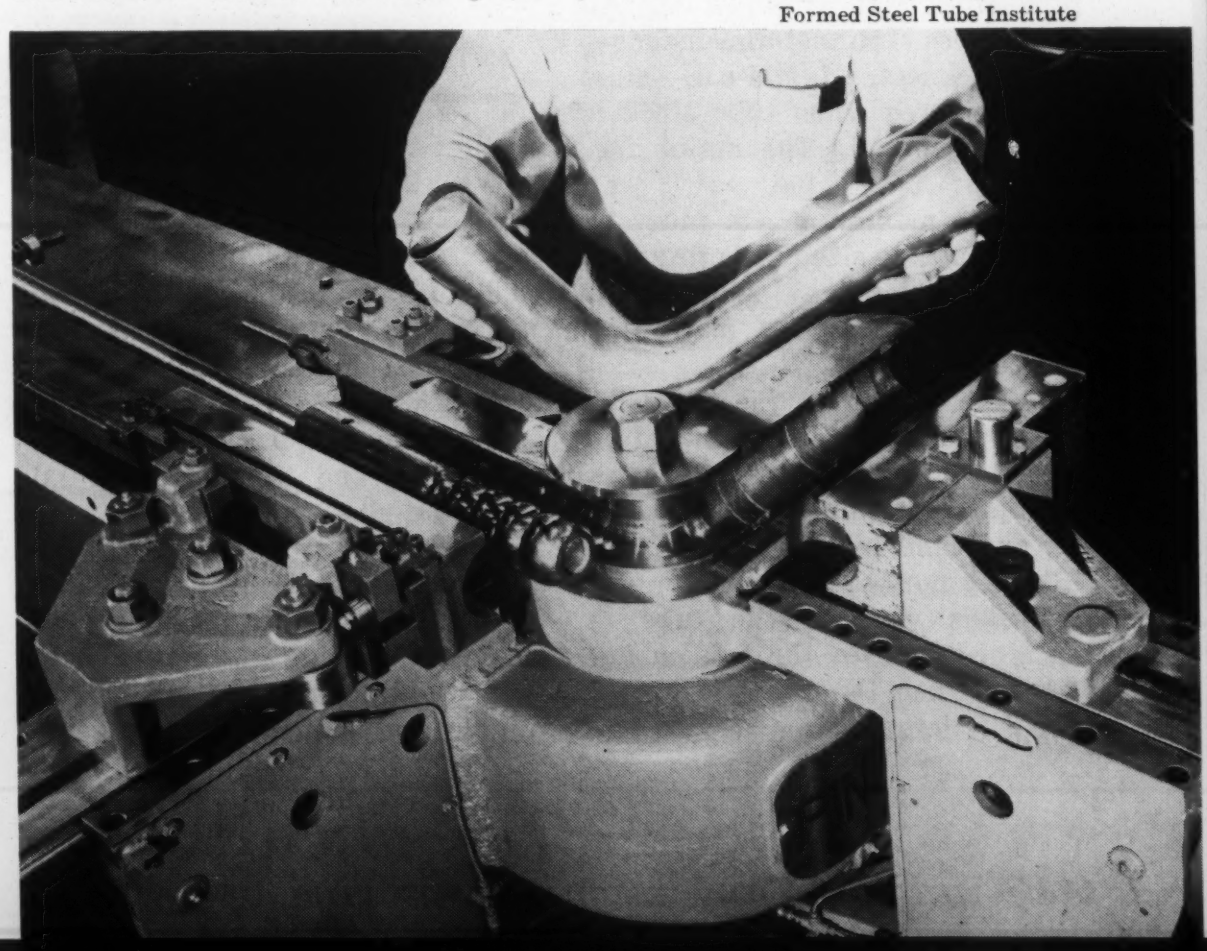
Practically all tube materials and tube sizes can be spun by either the hot or the cold method. One of the principal uses of spinning is to close the ends of the tubes. By proper manipulation of the forming tool, any one of a variety of shaped closures—such as flat, pointed or spherical—can be obtained. Spinning is also used for reducing the size and shaping portions other than the ends of tubes.

A modified cold spinning method, known as the Dewey process, can shape a straight piece of tube into varying contours. In this process, the tube, while rotating, is pulled through a forming unit and is shaped by a free-turning forming roll. The operation is usually performed in one pass. The spun tube is circular in all cross sections. Long pieces of tube can be pulled through the machine in such a way that a contour shape applied to a short section can be repeated successively. Later the tube can be cut up into individual pieces all having the same configuration.

Upsetting — In upsetting, the wall is thickened at one or both ends of the tube. Tubes can be upset on either the outside or the inside of the tube. On some materials, such as copper alloys, the operation is sometimes performed cold; on others, such as steel, the tube is heated locally on the end to be processed and then upset in a forging machine. The amount of upsetting that can be done depends on the material. For example, steel tube from 1 to 5 in. o.d. with ⅛-in. wall thickness or heavier can be upset as follows: The wall of the upset cannot exceed 1.8 times the original wall thickness, and the length of the upset cannot be longer than 15 times the original wall thickness, nor can it exceed 4 in. in length. The i.d. of the upset cannot be less than ⅝ in. These limitations are based on common commercial practice, but longer and heavier upsets are possible; also, larger diameter tubing than that given above can be upset.

Flanging, in which a flange or lip is formed on the end of the tube, is a modification of the outside upset operation. It is more severe and usually requires more than one forging operation.

Mandrel bending *requires a machine to which is attached a bending die and mandrel holder. The best grade of bends are made by this process.*
Formed Steel Tube Institute



Flaring—Flaring is a forming operation that widens the end of a tube to a funnel shape. The degree and amount of flaring possible on any given tube material depend upon the wall thickness, ductility and temper of the tube. Under certain conditions flaring can also be used to flange tubing.

Expanding—Expanding is similar to flaring but differs from it in that the enlarged end is parallel to the tube axis rather than being angled out in a funnel shape. As in flaring the amount of expansion possible depends upon the dimensions, ductility and temper of the tube. Expanding can be done either hot or cold.

Flattening and sealing — Flattening and sealing is a relatively simple operation accomplished in a press. For sealing, the tube end can be either pinched flat or crimped into a "W" shape. Flattening generally involves pressing the end of the tube flat without closing it completely.

Beading and grooving—This is done simply by forcing the tube against rolls. Either raised beads or grooves are possible. The width and depth of the beads or grooves can be varied to produce configurated tubes, but such operations are limited by the material, the properties and the wall thickness of the tube.

Machining—This is one of the most frequently used methods of producing parts from tube. All three cross-sectional dimensions—wall thickness, i.d. and o.d.—must be considered when tube stock is to be machined. The major factors are:

1. The maximum o.d. must be finish machine size (including plus machine tolerance) with additional allowances for machining and camber.

2. The minimum i.d. must be finish machine size (including minus machine tolerance) with additional allowances for machining and camber.

3. The method of chucking will determine whether the tube is machined true to the o.d. or i.d. If the former, the complete spread of o.d. tolerance is added to the o.d.; if the latter, the complete spread of i.d. tolerance is subtracted from the i.d.

4. The average wall thickness is the difference between the maximum o.d. and the minimum i.d. plus the plus wall tolerance.

Machinability of the various tube materials is about the same as that of solid stock of the same material. And in general the same equipment, i.e., lathes, and single and multiple-spindle semi-automatic and automatic screw machines, are used.

Drilling and piercing — These operations are generally done on a punch press by using a supporting arbor inside the tube. Light-walled tube is usually pierced; heavy-walled tube is drilled. Drill-produces burrs on the inside tube surface which it may be necessary to remove by reaming.

Joining—Tubing can be assembled by all the common welding

Carbon and alloy steel tubing—

PROPERTIES OF WELDED AND SEAMLESS TUBING

AISI Type	Condition	Tensile Strength, 1000 psi	Yield Strength, 1000 psi	Elongation (2 in.), %	Hardness[a]
WELDED TUBE[b]					
1010	As Welded	45	35	30	B60-75
	Normalized	40	23	35	B60
	Drawn	55	40	10	B70
1015	As Welded	48	36	25	B62-77
	Normalized	45	28	35	B65
	Drawn	60	45	10	B72
1020	As Welded	50	38	30	B65-80
	Normalized	48	30	30	B70
	Drawn	65	50	10	B75
1025	As Welded	55	40	25	B67-82
	Normalized	52	35	25	B75
	Drawn	70	55	20	B77
1030	As Welded	60	45	20	B68-83
	Normalized	60	40	25	B80
	Drawn	75	60	10	B80
SEAMLESS TUBE					
4118	Annealed	76	50	33	149
	Cold Drawn	97	63	21	207
	Normalized	93	55	33	179
4130	Annealed	81	52	28	156
	Normalized	97	63	25	197
	Water Quenched	144	129	18	293
4140	Annealed	95	60	26	197
	Normalized	148	95	18	302
	Hard. & Temp[c]	156	143	15	311
4150	Annealed	105	55	20	197
	Normalized	167	106	12	321
	Hard. & Temp[c]	175	160	14	352

[a]Brinell (no scale indication) or Rockwell.
[b]Over ¾ in. in dia.
[c]Oil quenched, tempered at 1000 F.

DIAMETER TOLERANCES FOR WELDED TUBING[a]

Diameter, in.[b]	Wall Thickness, BWG	Cold Rolled Carbon Steel				Hot Rolled Carbon Steel		
		Standard Tolerance[c]		Close Tolerance[d]		Standard Tolerance[c]		Close Tolerance[e]
		O.D., in.	I.D., in.	O.D., in.	I.D., in.	O.D., in.	I.D., in.	O.D., in.
¼ to ⅜	22 to 14	0.0025	0.009	—	—	—	—	—
	20 to 14	—	—	0.002	0.005	—	—	—
	16 to 14	—	—	—	—	—	—	0.002
⅜ to ⅝	22 to 16	0.003	0.005	—	—	—	—	—
	20 to 12	—	—	0.0025	0.0025	—	—	—
	16 to 12	—	—	—	—	—	—	0.0025
	14 to 12	0.003	0.009	—	—	—	—	—
⅝ to 1⅛	22 to 14	0.0035	0.005	—	—	—	—	—
	20 to 11	—	—	0.0025	0.0025	—	—	—
	16 to 11	—	—	—	—	0.0035[f]	0.012[f]	0.0025
	13 to 11	0.0035	0.008	—	—	—	—	—
1⅛ to 2	22 to 14	0.005	0.006	—	—	—	—	—
	20 to 9	—	—	0.003	0.003	—	—	—
	16 to 14	—	—	—	—	0.005	0.010	—
	16 to 9	—	—	—	—	—	—	0.003
	13 to 9	0.005	0.008	—	—	—	—	—
	13 to 7	—	—	—	—	0.005	0.015	—
2 to 2½	20 to 14	0.006	0.007	—	—	—	—	—
	20 to 9	—	—	0.004	0.004	—	—	—
	16 to 14	—	—	—	—	0.006	0.012	—
	16 to 9	—	—	—	—	—	—	0.004
	13 to 9	0.006	0.009	—	—	—	—	—
	13 to 6	—	—	—	—	0.006	0.016	—
2½ to 3	20 to 18	0.008	0.012	—	—	—	—	—
	18 to 9	—	—	0.005	0.005	—	—	—
	16 to 14	—	—	—	—	0.008	0.012	—
	16 to 9	0.008	0.010	—	—	—	—	0.005
	13 to 4	—	—	—	—	0.008	0.016	—
3 to 3½	20 to 9	0.009	0.012	—	—	—	—	—
	16 to 14	—	—	—	—	0.009	0.015	—
	13 to 4	—	—	—	—	0.009	0.020	—
3 to 4	18 to 8	—	—	0.006	0.006	—	—	—
	16 to 8	—	—	—	—	—	—	0.006
3½ to 4	20 to 8	0.010	0.015	—	—	—	—	—
	16 to 14	—	—	—	—	0.010	0.017	—
	13 to 4	—	—	—	—	0.010	0.021	—
4 to 5	16 to 14	0.020	0.020	—	—	0.020	0.022	—
	13 to 8	0.015	0.018	—	—	—	—	—
	13 to 4	—	—	—	—	0.015	0.026	—

[a]Round tubing. All values are ±.
[b]Range is not inclusive of lower value.
[c]Flash controlled to 0.005-in. max.
[d]Mandrel flash removed.
[e]Without mandrel. Same values hold for cold rolled close tolerance without mandrel.
[f]Diameter range for this tolerance is actually ¾ to 1⅛ in.

and mechanical joining methods. Weldability of a given tube is the same as that of the metal in solid form. The conventional method of butt-joining small and medium diameter tubes is flash welding. Tube assemblies often lend themselves to brazing.

Mechanical methods used for joining tubing include bolting or riveting, huck riveting, telescoping, joining with drive screws or self-tapping screws, flattening and bolting, threading and coupling, and compression fitting.

Carbon and alloy steel tubing—properties and tolerances (continued)

WALL THICKNESS TOLERANCES FOR WELDED TUBIN

Wall Thickness		Wall Thickness Tolerance, in.[b]	
BWG	In.	Cold Rolled	Hot Rolled
22	0.028.....	+0.000, −0.003	—
20	0.035.....	+0.000, −0.004	—
18	0.049.....	+0.000, −0.004 to −0.005	—
16	0.065.....	+0.000 to +0.002, −0.004 to −0.007	+0.002, −0.006 to −0.010
14	0.083.....	+0.000 to +0.002, −0.004 to −0.007	+0.002 to +0.003, −0.006 to −0.012
13	0.095.....	+0.000 to +0.002, −0.004 to −0.007	+0.002 to +0.003, −0.006 to −0.012
12	0.109.....	+0.000 to +0.003, −0.006 to −0.009	+0.002 to +0.005, −0.006 to −0.012
11	0.120.....	+0.000 to +0.003, −0.006 to −0.009	+0.002 to +0.005, −0.008 to −0.012
10	0.134.....	+0.000 to +0.003, −0.006 to −0.009	+0.002 to +0.005, −0.008 to −0.012
9	0.148.....	+0.000 to +0.003, −0.006 to −0.009	+0.002 to +0.005, −0.008 to −0.012
8	0.165.....	+0.000 to +0.003, −0.007 to −0.010	+0.002 to +0.005, −0.008 to −0.012
7	0.180.....	—	+0.002 to +0.005, −0.008 to −0.012
6	0.203.....	—	+0.002 to +0.005, −0.010 to −0.013
5	0.220.....	—	+0.002 to +0.005, −0.010 to −0.013
4	0.238.....	—	+0.002 to +0.006, −0.010 to −0.018
—	0.250.....	—	+0.006 to −0.018

[a]Round tubing.
[b]Ranges are given because tolerance varies with o.d.

TOLERANCES FOR SEAMLESS TUBING[a]

Diameter, in.[b]	Cold Finished[c]				Hot Finished
	Finish Annealed		Soft Annealed		
	O.D. Tol, in.	I.D. Tol, in.	O.D. Tol, in.	I.D. Tol, in.	O.D. Tol, in.[j]
3/16 to 1/2.....	±0.004[e]	—	+0.006, −0.002	—	±0.023
1/2 to 1 1/2.....	+0.005[d, e, f]	−0.005[d, e, f]	+0.008,[d, e, f] −0.002	+0.002,[d, e, f] −0.008	±0.023
1 1/2 to 3 1/2....	+0.010[d, e, f]	−0.010[d, e, f]	+0.015,[d, e, f] −0.005	+0.005,[d, e, f] −0.015	±0.023
3 to 5 1/2.....	+0.015[d, f]	+0.005,[d, f] −0.015	+0.023,[d, f] −0.007	+0.015,[d, f] −0.025	±0.031
5 1/2 to 8.....	±0.030[f, g] ±0.020[h] +0.030[d]	±0.035[f, g] ±0.025[h] +0.015,[d] −0.030	±0.060[f, g] ±0.040[h] +0.0,45[d, i] −0.015	±0.070[f, g] ±0.050[h] +0.037[d, i] −0.053	±0.047
8 to 10 3/4.....	±0.045[f, g] ±0.035[h] +0.045[d, i]	±0.050[f, g] ±0.040[h] +0.015,[d, i] −0.040	— — —	— — —	±0.047[k] ±0.063[l]

[a]Round tubing. [b]Below 8 in., ranges are not inclusive of higher figure.
[c]Wall thickness tolerance is 10% except 15% for 3/16 to 1/2 in. dia.
[d]For tubes which cannot be successfully drawn over a mandrel (often true of those with: 1) i.d. <50% of o.d., 2) wall >25% of o.d., 3) wall >1 1/4-in. thickness, 4) weight >90 lb per ft, the i.d. tolerance is ±10% of the wall thickness and the wall thickness tolerance is 12%.
[e]For certain other tubes which are not commonly drawn over a mandrel (specifically, those with i.d. <1/2 in., or with i.d. <5/8 in. when wall thickness >20% of o.d.), the wall thickness tolerance is 15% and the i.d. is governed by the standard tolerances for o.d. and wall thickness.
[f]Tubes with wall <3% of o.d. cannot be straightened properly without distortion and require an additional ovality tolerance of ±1/2% for the o.d. and i.d.
[g]When wall <5% of o.d. [h]When 5% of o.d. <wall <7.5% of o.d.
[i]When wall >7.5% of o.d.
[j]Wall thickness tolerance: ±16.5% for wall thickness less than 0.109 in.; ±15% for 0.110 to 0.172 in.; ±14% for 0.173 to 0.203 in.; 12.5% for thicker walls.
[k]When wall >5% of o.d. [l]When wall <5% of o.d.

Steel Tubing

Mechanical steel tubing is divided into two main classes—seamless and welded—and each of these is subdivided according to variations in the method of production and finishing.

Seamless steel tubing

There are three methods of producing seamless tubing in sizes up to 26-in. o.d.:

1. *Rolling, drawing*—The method most used for mechanical tubing involves hot piercing solid steel billets or bars and reducing their size by either hot rolling or hot drawing, or by a combination of both.

2. *Extrusion*—Hot extrusion is a method for making hollows, which are suitable for processing into finished tubing, by forcing prepierced billets through a suitably shaped orifice formed by external die and internal mandrel. It is most advantageous when producing tubing of irregular cross section.

3. *Cupping, drawing* — Steel plate is hot cupped and then hot drawn to size. Hot cupping is seldom used for sizes under 9 in.

Tubing which is put into service without further processing is known as hot finished tube. Its surface finish is like that of other hot rolled steel products. If the hot finished tubing is further processed it is commonly designated as "cold finished (cold worked)" or "cold finished (surface removal)" depending on the method of processing used.

1. *Cold working* is used primarily for the purpose of obtaining smaller diameters, better finishes, thinner walls, and closer dimensional accuracy than is possible in hot finished tubing. In addition, mechanical properties and machinability are improved.

Of the different cold working

processes, those such as swaging, spinning, etc., have already been discussed under "forming methods." The principal one of concern here is cold drawing. In this case the tube is externally drawn through a cold reduction die and simultaneously internally drawn over a mandrel or a full length bar serving as a mandrel. Cold drawing through a die only, without a mandrel, is referred to as "sink drawing" or "sinking" and is usually necessary under certain limiting conditions stated in the footnotes of the tolerance tables (p 134). The cold drawing operation is often repeated a number of times to reach the final dimensions, and in such cases the tube is annealed between passes to remove cold working stresses.

2. *Surface removal of metal* is accomplished by machining, grinding or polishing, and is used primarily to produce particular surface finishes or very close diameter tolerances. Cold worked tubing may also be subjected to such processes.

Materials—In addition to the stainless steels and the basic carbon steels, over two hundred standard alloy steels are produced. Seamless tubing is supplied in almost all these compositions, although not always stocked as a standard item. In addition, it can be had in special analyses to meet specific service requirements. Properties of any alloy vary with supplier and process. For these reasons, it is not practical to provide an extensive list of mechanical properties. The table on p 132 covers a few alloy steels in the important 4100 series.

Although it is necessary to consult the supplier before selecting an alloy for mechanical tubing, a brief statement of the effect of certain alloying elements may be helpful.

Carbon. The principal hardening element in steel. As the percentage of carbon increases (up to about 0.85%) hardness and tensile strength increase and ductility and weldability decrease.

Manganese. Contributes to strength and hardness and is beneficial to surface quality. High carbon steels are more affected by manganese than low carbon steels.

Phosphorus. Increases strength and hardness at the sacrifice of ductility. It improves resistance to atmospheric corrosion and improves machinability in the low carbon steels.

Sulfur. Makes steel more machinable. It has little effect on hardness or longitudinal mechanical properties, but decreases transverse ductility and impact toughness.

Silicon. Principal deoxidizer used in steel making. It is less effective than manganese in increasing strength and hardness.

Copper. Aids corrosion resistance. The small amounts used have no effect on mechanical properties but are detrimental to surface quality. None of the conventional steelmaking processes removes the copper.

Fabrication—Seamless mechanical tubing can be fabricated by practically all the common forming methods listed earlier in the manual. However, cold drawn tubing in the finish annealed condition, with its moderate ductility, cannot undergo severe forming operations while cold, and so should be soft annealed for maximum workability.

Although the machinability of low carbon seamless tubing in the finish annealed condition is not equal to that of screw steels and other free-cutting bar stock, it is suitable for all cutting operations, and relatively good machining results can be obtained. For screw machine work or where a large amount of machining is required, tubing of a free-cutting grade such as AISI 1118 is usually recommended. Machinability improves with cold work; therefore hard drawn tubing shows the best machinability.

Available forms — Cold drawn seamless tube is most generally furnished in the finish annealed condition. However, it can be had in other conditions to meet specific physical requirements. The common heat treatments or conditions in which the finished tube are available are: unannealed, soft annealed, medium annealed, normalized, finish or stress relief annealed, and hard drawn.

Seamless tubing is available in a wide range of standard diameters and wall thicknesses. Hot finished tube ranges in o.d. from 1½ to 10¾ in. and in wall thickness from 0.095 to 2 in. Cold drawn tubes are produced in standard sizes ranging from 3/16-in. o.d. by 0.035 in. to 10½-in. o.d. by 2 in. Specialty tubing can be produced in extremely small sizes. An accompanying table (p 134) gives the tolerances obtainable on standard sizes. Although the standard and most used shape of seamless tubing is round, other special sections are readily available.

The surface finish of seamless tube depends primarily on the method of manufacture. Cold drawn tube is relatively smooth, but generally has slight surface marks caused by drawing, heating, pickling, straightening and handling. Five higher grades of finish listed in the Steel Products Manual (AISI) are available on cold drawn tube to meet special applications. These are:

Class 1. Surface is free of all imperfections after removal of a definite maximum amount of o.d. stock to make it suitable for plating.

Class 2. Surface is free from all surface defects as shipped, except for light scores and pits.

Class 3. Surface has either cylinder or piston finish. Piston finish is free of longitudinal scores on outside; cylinder finish is free of longitudinal scores on inside.

Class 4. Outside surface is suitable for plating without previous polishing or buffing.

Class 5. Surfaces are polished and finish is superior to the other classes.

Welded steel tubing

All welded tubing is produced from flat rolled stock—skelp, plate or strip — and is formed and welded by one of several methods. Furnace welding is the oldest and is used to produce both butt welded and lap welded tubes. In both

cases the stock is heated in a furnace. For butt welding the stock, after reaching welding temperature, is drawn through a funnel-shaped welding die (or through welding rolls in a continuous operation) and shaped into tubular form. The edges are brought together with sufficient pressure to weld. For lap welding, the stock is shaped to tubular form with edges overlapping, reheated, and then welded by pressing together the overlapping edges. Lap welding is used for larger diameter tubing.

Newer methods involve cold forming of the flat steel through a series of rolls and then butt welding by either fusion or electric resistance welding. In electric resistance welding, electric current supplies the heat and the joint is effected under pressure. In the fusion method, atomic hydrogen, oxyacetylene or an electric arc is used to make the joint. No pressure is required. No filler metal is used, generally, except with arc welding. After welding, the flash on the inside may or may not be removed depending on the intended use of the tube.

Welded tubing can be further reduced, both in outside diameter and wall thickness, by cold drawing methods similar to those used on seamless tube. Cold reduction is done when other than standard sizes or shapes are required or when special mechanical properties are desired.

Materials — Welded tubing is manufactured from both cold rolled and hot rolled steel. Cold rolled steel is most suitable for light gage tube, for applications where close tolerances must be met, or for applications where close control of temper or hardness is required. Also, the higher quality finish on tubing made of cold rolled steel recommends it for uses where polishing, plating or lacquering is necessary. Hot rolled steel tubing is used when heavy forming operations are to be carried out. In addition, organic finishes have better adhesion on the rougher surface.

Welded steel tubing is available in practically all the carbon steel grades up to 0.34 carbon, and up to 0.55 carbon on special order. Weldable alloy and stainless steel types are also available. The most commonly used carbon steels, with their properties, are listed on p 132.

In general, mechanical properties of welded tube in the as-welded condition are comparable to those of the flat stock analysis from which the tube is made. The strength properties of as-welded tube are lower than those of cold drawn tube, but ductility is higher. Temper can be varied, or further cold work can be performed, to meet specific mechanical property requirements. In addition, mechanical properties can be increased by cold working the flat stock before forming into tube. This is done, for example, on tube stock for automobile propeller shafts.

Fabrication—Like seamless tubing, welded tubing can be formed and fabricated by such methods as expanding, beading, flanging, bending and tapering. Fabricating properties, such as hot and cold workability, weldability and machinability, are again comparable to those of the flat stock analysis. The welded seam is as capable as the tube of withstanding the cold forming operations. In fact, in practically all respects welded tube is homogeneous and can be treated as though no weld were present.

Available forms—As-welded tubing is available in a range of standard sizes from ¼ to 5½ in. and in wall thicknesses from 0.025 to 0.120 in. (cold rolled) or 0.065 to 0.259 in. (hot rolled). In general, the ratio of outside diameter to wall thickness should not be less than 10 to 1. Tolerances range from ±0.002 in. on smaller diameter tubes to proportionally greater tolerances on large diameters. In most cases, these tolerances are also applied to shapes other than round.

As mentioned previously, the finish depends largely on whether the tube is made from hot or cold rolled stock. In either case, the inside and outside surfaces are smooth and free of scale. Higher grade finishes can be obtained on request.

Welded tubing may be cold drawn after welding for any one of several reasons: 1) to provide o.d., i.d. or wall thickness other than standard; 2) to obtain closer dimensional tolerances; 3) to form cross-sectional shapes other than round; and 4) to obtain special mechanical properties. Cold drawn welded tube generally has a somewhat better finish than tube in the as-welded condition. It also has higher strength and hardness, but lower elongation.

Stainless steel tubing

Materials—The stainless steel tubular products listed in the tables on p 137 are iron-base alloys containing a minimum of 10.5% chromium, with or without additions of other elements. Of the other elements, carbon, nickel and manganese are of basic importance, whereas such elements as silicon, molybdenum, titanium, columbium, tungsten, copper, vanadium, and aluminum are added to obtain special characteristics.

The stainless steels most commonly used for tubing may be subdivided into the following groups:

1. The iron-chromium alloys which cannot be hardened by heat treatment but are hardenable by cold working (such ferritic alloys as 430). They possess excellent oxidation resistance but low high-temperature strength.

2. The iron-chromium-nickel alloys hardenable only by cold working (the austenitic alloys of the 300 series). These are more ductile and offer greater impact strength.

Types of service for which these steels are used are: corrosion resistance, heat resistance, cold resistance, architectural or ornamental, mechanical, and aircraft.

Available forms — Mechanical tubing is manufactured in both welded and seamless forms by the conventional methods described earlier. Seamless tubing can be furnished in either hot finished or cold finished form. The hot fin-

Stainless steel tubing—properties and tolerances

PROPERTIES OF WELDED TUBING[a]

Type	Ten Str, 1000 psi	Yld Str, 1000 psi	Elong (2 in.), %	Izod Impact Str, ft-lb	Rockwell Hardness	Uses
302	90-95	35-45	50-60	110	B85	Architectural, automotive, hospital equipment; air preheaters, furnace parts
304	85-95	30-40	50-60	110	B80-90	Processing equipment for dairy, beverage, chemical, paper, textile industries
309S	90-100	35-45	45-55	100	B85	Combustion tubes, heater tubes, furnace parts
310	95-110	40-50	40-50	90	B85	Equipment for chemical, petroleum industries; furnace parts
314	90-110	40-50	40-50	90	B90	Equipment for chemical, petroleum industries; furnace, jet aircraft parts
316	85-90	35-45	50-60	100-110	B85	Marine and refrigeration applications; equipment for chemical, pharmaceutical, paper, textile industries
317	85-95	35-45	40-50	110	B85	Chemical and paper processing equipment
321	85-90	30-40	50-55	80-110	B80	Aircraft; other applications where not possible to anneal
347	90-95	35-45	45-55	100-110	B85	Aircraft and chemical equipment; welded applications where not possible to anneal
430	75-85	35-45	25-40	15-40	B80	Chemical, automotive equipment

[a]Round tubing, annealed.

TOLERANCES[a]

Diameter, in.[b]	Diameter Tolerances[c]			Wall Thk, in.	Wall Thk Tol for Welded Tubing, in.[d, e]
	Seamless O.D. Tol, in.	Welded			
		O.D. Tol, in.	I.D. Tol, in.		
Up to 3/32	0.005	0.001	0.001	0.025	0.002-0.003
3/32 to 3/16	0.005	0.0015	0.0015	0.028	0.003
3/16 to 1/2	0.005	0.003	0.005	0 032	0.003-0.004
1/2 to 1	0.005	0.004	0.006	0.035	0.003-0.005
1 to 1 1/2	0.005	0.005	0.007	0.042	0.003-0.005
1 1/2 to 2	0.010	0.006	0.008	0.049	0.003-0.005
2 to 2 1/2	0.010	0.007	0.010	0.058	0.004-0.006
2 1/2 to 3 1/2	0.010	0.010	0.014	0.065	0.005-0.006
3 1/2 to 5	0.015	0.015	0.020	0.072	0.005-0.007
3 1/2 to 5 1/2	0.015	—	—	0.083	0.005-0.007
5 1/2 to 8	0.030	—	—	0.095	0.005-0.007
8 to 8 5/8	0.045	—	—	0.109	0.005-0.007
				0.120	0.005-0.007
				0.134	0.007
				0.149	0.008
				0.165	0.008

[a]Round tubing; annealed or as cold finished. All values are ±.
[b]Ranges are not inclusive of upper values.
[c]Tolerances are general and subject to limitations by D/t ratio. Ovality tolerance is generally double the o.d. tolerance.
[d]Wall thickness tolerance for seamless tubing is generally ±10% except 15% when o.d. <1/2 in.
[e]Ranges are given because tolerance varies with o.d.

ished type is more difficult to process than plain carbon tubing and the finish is usually inferior. It is not suitable for polishing. All hot finished tubing is supplied in the annealed condition with surfaces cleaned by pickling or shot blasting. The seamless cold finished type is furnished in the annealed condition with pickled surfaces. It is suitable for grinding or polishing within certain size limitations.

Welded stainless steel tubing is available in ornamental grades as well as mechanical. The mechanical grades are supplied in the annealed condition with pickled surfaces; the ornamental grades in the as-welded (flash in) condition. The tubing can be ground or polished, and standard sizes range from about 1/4 to 4 1/2-in. o.d. with wall thickness from 0.020 to 0.134 in. Round, rectangular and special shapes are available. Both small and large diameter tubing are produced as specialty items.

Centrifugally cast tubing

Centrifugal spinning is now used to produce tubing of alloy iron and carbon and alloy steel when required in extremely large

sizes and in large quantities. The casting is spun on a horizontal axis and a centrifugal force of 75 times gravity holds the molten metal on the wall of the mold and eliminates the necessity for a center core. Impurities are forced to the inside surface for removal by machining.

Tubing for radial engine cylinder barrels, cylinder sleeves and bearings are produced in metal molds. Longer tubes for paper mill rolls, hydraulic cylinders and refinery applications are most economically made in sandlined refractory molds. Many other parts —wheel hubs, pump liners, hoist drums, seat rings and bushings— are machined from centrifugally spun steel tubes.

The tubes are supplied in lengths up to 16 ft but tubes can be welded together for longer lengths. Outside diameters range from 2.25 to 50 in., wall thicknesses from 0.25 to 4.0 in. Tubes can be heat treated and quenched when specific physical and mechanical properties are required.

As-cast tolerances are ±0.10 in. for o.d. of 3.00 to 13.55 in., ±0.12 in. for o.d. of 13.56 to 26.75 in., ±0.16 in. for o.d. of 26.76 to 37.70 in., and ±0.20 for o.d. of 37.71 to 50.25 in. Wall thickness is subject to ±8% variation unless tubing is specified for boring.

In general, spun tubing offers high strength values, nondirectional mechanical properties, dimensional stability and improved machinability.

Copper and copper alloy tube—MECHANICAL AND

Type[a]	Ten Str, 1000 psi		Yld Str, 1000 psi[b]		Elong (2 in.), %	
	Hard	Soft	Hard	Soft	Hard	Soft
Copper[e]	50	33	45	9	9	45
Copper[f]	55	32	51	9	8	45
Commercial Bronze	60	38	53	12	6	50
• Silicon Bronze	65	43	45	18	14	53
• Cupro-Nickel (10%)	66	48	61	23	10	40
• Phosphor Bronze	67	44	54	17	11	49
Red Brass	70	40	57	13	9	59
Low Brass	74	44	60	13	8	60
Leaded Brass	75	49	60	19	8	55
• Naval Brass	75	54	50	25	20	50
• Cupro-Nickel (30%)	75	58	68	24	7	45
Cartridge Brass	77	47	63	16	9	63
Muntz Metal	80	54	60	20	6	40
• Aluminum Brass	85	56	60	24	10	60
• Admiralty	93	53	80	21	6	65

[a]Composition not given because values are average for particular alloy and may involve slight variation in composition. Alloys preceded by a dot (•) are classified "refractory," others "nonrefractory."
[b]0.5% extension under load.

TOLERANCES FOR SEAMLESS TUBE[a]

Diameter, in.[d]	Mean Diameter Tolerances, in.[b]		Wall Thickness, in.[e]	Wall Thickness Tolerances, in.[c]	
	Nonrefractory	Refractory		Nonrefractory	Refractory
Up to ⅛	0.002	0.0025[f]	Up to 0.018	0.001-0.002	0.0015-0.0025
⅛ to ⅝	0.002	0.0025	0.018 to 0.025	0.002-0.003	0.0025-0.004
⅝ to 1	0.0025	0.003	0.025 to 0.035	0.0025-0.004	0.003-0.005
1 to 2	0.003	0.004	0.035 to 0.058	0.003-0.007	0.004-0.009
2 to 3	0.004	0.005	0.058 to 0.083	0.0035-0.010	0.0045-0.013
3 to 4	0.005	0.006	0.083 to 0.120	0.004-0.011	0.005-0.014
4 to 5	0.006	0.008	0.120 to 0.165	0.005-0.012	0.007-0.015
5 to 6	0.007	0.009	0.165 to 0.220	0.007-0.014	0.009-0.018
6 to 8	0.008	0.010	0.220 to 0.284	0.009-0.016	0.012-0.020
8 to 10	0.010	0.013	0.284 to 0.380	0.011-0.018	0.015-0.023
			0.380 and over	5%-6%	6%-8%

[a]Round tubing. All values are ±.
[b]Tolerances apply to i.d. or o.d. except where otherwise indicated.
[c]Maximum deviation at any point; range indicates variation with o.d.
[d]Ranges are not inclusive of lower values.
[e]Ranges are not inclusive of upper values.
[f]O.d. only; value for i.d. is 0.003 in.

Aircraft tubing

Although space does not permit detailed discussion of aircraft tubing, it deserves passing mention because it can often be used to advantage where special properties are required or where the tube will undergo special processing that will affect the surface.

Aircraft mechanical tubing is the term used to describe cold drawn or hot finished carbon or alloy steel tubing used in aircraft construction for parts requiring virtually complete removal of the outside surface, inside surface, or both. Because the surfaces will be destroyed or removed during fabrication, the tubes are supplied with a relatively wide tolerance, both in size and surface finish. Aircraft tubing is the same as regular mechanical tubing except that aircraft quality steel (or other special analyses) and particular physical properties may be specified.

"Aircraft (or Airframe) quality tubing" is a term which refers to tubing made of aircraft quality steel. Such tubing may be seamless, cold drawn, as-welded, or welded and drawn tubing. It is produced to specified finish and dimensional tolerances for use in parts where machining or heat treatment of the tube is not required. However, in some in-

properties and tolerances

FABRICATING PROPERTIES

Rockwell Hardness		Cold Work[c]	Hot Work[c]	Machinability[d]	Uses
Hard	Soft				
B55	F40	A	A	20	Liquid conveyer lines—petroleum, food, paper industries
B60	F40	A	A	20	Electrical bus tubing; appliance and wiring terminals
B69	F57	A	B	20	Projectile rotating bands; outdoor hardware
B75	F62	A	A	30	Where high physical properties are specified
B75	B25	A	B	20	Particularly resistant to salt or brackish water
B77	F60	A	B	20	Pole-line hardware for electrical transportation
B77	F60	A	B	30	Aircraft radiators; marine use; pump liners
B80	F62	A	B	30	Metal bellows; heating appliances; pump liners
B80	F70	B[g]	D	70[h]	General purpose yellow brass; heavy machining operations
B80	B55	C	A	30	High corrosion resistance; aircraft turnbuckles
B81	B38	A	C	20	High ductility; resistant to corrosion and erosion
B83	F64	A	C	30	Severe forming operations; plumbing and auto applications
B85	F80	C	A	70	Heavy-walled and large diameter tubes; screw operations
B85	F77	B	C	30	Better suited than Admiralty for resisting velocity failure
B95	F75	B	D	30	Fins in corrosion applications; standard condenser tube alloy

[c]A = excellent, B = good, C = fair, D = poor.
[d]Free-cutting brass = 100.
[e]Deoxidized.
[f]Electrolytic tough pitch.
[g]A for low-leaded; C for free cutting.
[h]60 for low-leaded; 80 for free cutting.
[j]Free-cutting.

stances this tubing can be formed, partially machined, ground or heat treated by the user. It can be supplied normalized, stress relieved, annealed or heat treated. It is commonly produced in relatively thin wall sizes (0.022 to 0.250 in.) ranging from 3/16 to 3½-in. o.d.

Aircraft stainless steel mechanical (also referred to as structural) tubing, seamless or welded, is commonly used in exhaust systems. In some cases it is produced for parts that are to be machined. Usual size range is from 1/16 to 5-in. o.d. and 0.010 to 0.250-in. wall thickness.

Copper Alloy Tube

In the copper and brass industry tubular products are divided into four basic classes. Condenser and heat exchanger tube, the major class, is outside the scope of this article. The class corresponding to mechanical tubing is commonly referred to as "commercial tube."

Practically all copper and brass tube is of the seamless type. There are about 16 different alloys generally available, ranging from soft copper to the harder, stronger aluminum brass and admiralty metal. The table above lists the most commonly used alloys with their mechanical properties, fabricating characteristics and uses.

Tubes such as copper and Muntz metal, which are readily hot worked, are produced as heavy-walled tube by the Mannesman piercing process and then cold drawn to finished dimensions. Many of the other alloys are hot extruded to form a tube with a heavy wall. Those more difficult to draw, such as cupronickel, are reduced in both diameter and wall thickness by a rolling operation. Regardless of the preliminary forming method, the tubing is finally brought down to required size by a number of drawing and annealing operations. Larger size tube is sometimes made by casting a heavy-walled shell and then reducing to size by a number of cold drawing operations.

Copper and brass commercial tube is commonly available in a wide range of sizes and shapes. Although plain round tube is most widely used, all the shapes listed previously (p 128) are available. Preferred sizes of copper and copper alloy round seamless tube normally run from about ⅛ to 12-in. o.d. and from 0.010 to ⅝-in. wall thickness. More specialized tubing includes small diameter sizes from 0.032 to ¾-in. o.d. with wall thickness from 0.005 to 0.095 in. as well as large diameter tubes and shells in sizes up to 26.875-in. o.d. and 0.437-in. wall thickness. Tolerances are listed in the table on p 138.

Unless otherwise specified, tube is supplied with the drawn finish —a finish which is relatively smooth and has a bright appearance. In extruded tube the surface is slightly oxidized and has a dull appearance. Many other types of finishes can be obtained on

Nickel and nickel alloy tubing—properties and tolerances

PROPERTIES OF SEAMLESS TUBING[a]

Type➡	A Nickel	Monel	K Monel	Inconel	Inconel X
Tensile Strength, 1000 psi					
Annealed	< 80	< 85	< 105	< 100	< 140
Half Hard	70-95	85-105	100-135	105-125	150-185
Full Hard	95-120	110-130	130-150	130-160	185-235
Yield Strength, 1000 psi					
Annealed	10-35	25-45	40-65	30-50	45-80
Half Hard	40-70	55-80	65-90	55-95	85-125
Full Hard	75-105	90-120	90-110	105-140	130-170
Elongation (in 2 in.), %					
Annealed	50-33	50-30	45-25	50-35	35-60
Half Hard	35-12	30-12	25-10	25-13	15-30
Full Hard	10-4	10-3	15-4	15-2	3-12
Hardness (Rockwell)					
Annealed	< B70	< B75	< B90	< B90	< C29
Half Hard	B75-90	B75-97	B90-C18	B90-C20	C30-38
Full Hard	B90-105	B95-C27	C18-26	C19-35	C39-47
FABRICATING PROPERTIES	Easily fabricated; strength and hardness increased by cold working, but not by heat treating	Forming operations not difficult; machining requires slow feed and deep cut; high strength obtained by cold drawing	Age hardening.[b] Can be heat treated to higher strength than most other corrosion resistant alloy tubing	High strength obtained by cold working; more power needed for forming larger radii for bending; machinability similar to Monel	As strong as heat treated steels in solution treated and aged condition
GENERAL CHARACTERISTICS	Mechanical properties compare with those of mild steel; retains high strength at elevated temperatures; scale resistant	Suited to all-purpose use; outstanding for ability to withstand wide range of corrosives	Combines corrosion resistance of Monel with high strength and hardness	Combines strength, toughness and corrosion resistance of nickel with high temperature properties of chromium	High strength; corrosion, high temperature and oxidation resistant
USES	In contact with foods, reducing acids, chemical process liquors, caustics, rayon, pharmaceuticals, plastics. Recording pens, watch bracelets, eyeglass frames	Chemical and processing equipment, pulp and paper machinery, food processing equipment, petroleum apparatus, marine applications, surgical and medical instruments	Precision instruments, torque tubes in liquid-level controllers, sleeves and bushings in pumps and valves handling salt water, fishing rod and reel parts	Jet and rocket engines, muffle tubes, aircraft fire detection systems, thermocouple protection tubes, surgical instruments, pharmaceutical processing equipment	Structural braces in jet engine after burners, temperature probes, atomic power applications

[a]Round cold drawn tubing. These materials are also available in welded tubing with similar properties.
[b]K Monel does not require a preliminary quench before hardening, and does not over-age.

TOLERANCES FOR SEAMLESS TUBING[a]

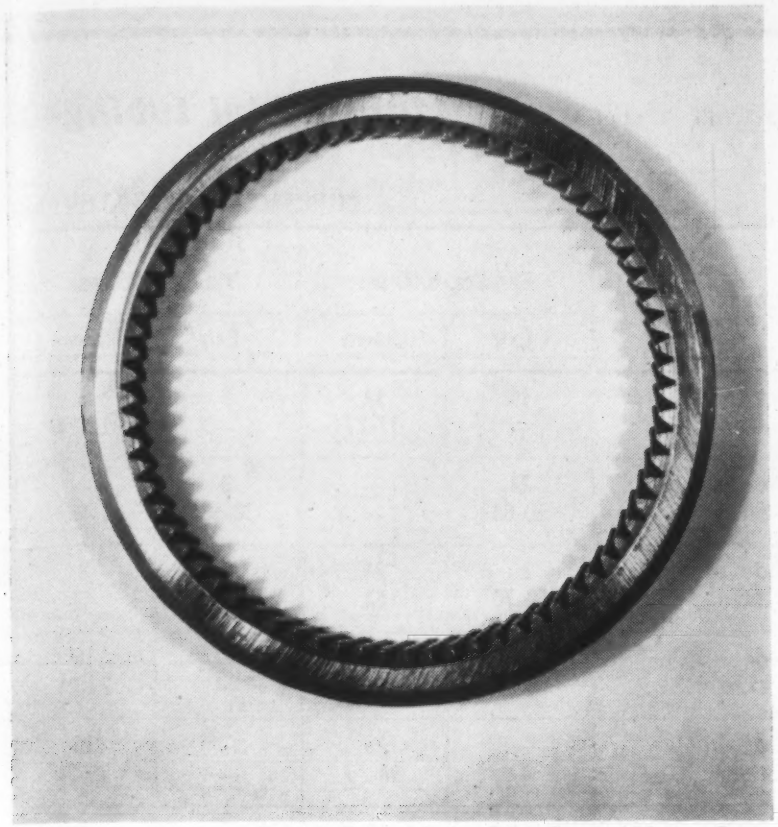
Diameter, in.	Dia Tol, in.[b,c]	Wall Thk Tol, %[b]
Monel, A Nickel, Low Carbon Nickel		
Up to 5/8	+0.005	12.5
5/8 to 1½	0.005	10
1½ to 4½	0.010	10
4½ to 6	0.015	12.5
6 to 7½	0.020	12.5
7½ to 8⅝	0.025	12.5
Inconel, Inconel X, K Monel, Incoloy		
Up to 5/8	0.005	15
5/8 to 1½	0.0075	10
1½ to 3½	0.010	10
3½ to 4½	0.015	10
4½ to 6	0.020	12.5
6 to 6⅝	0.025	12.5

[a]Round cold drawn. All tolerances ± except where otherwise indicated. Tolerances given here are applicable only to two dimensions at a time. Diameter ranges are not inclusive of lower values.
[b]The following applies only to tubes which cannot be successfully drawn over a mandrel: 1) If i.d. <50% of o.d., the i.d. tolerance is ±10% of the wall thickness and the wall thickness tolerance is 12½% for alloys in top part of table, 15% for others; 2) if i.d. <½ in., the i.d. will be governed by standard tolerances for o.d. and wall thickness.
[c]Tubes with wall <3% of o.d. cannot be straightened properly without distortion and require an additional ovality tolerance of ±½% for the o.d. and i.d. Tubes furnished in soft annealed temper may possess ovality because of warpage during annealing or straightening and will not have tolerances as close as table indicates.

special order; plating is readily accomplished.

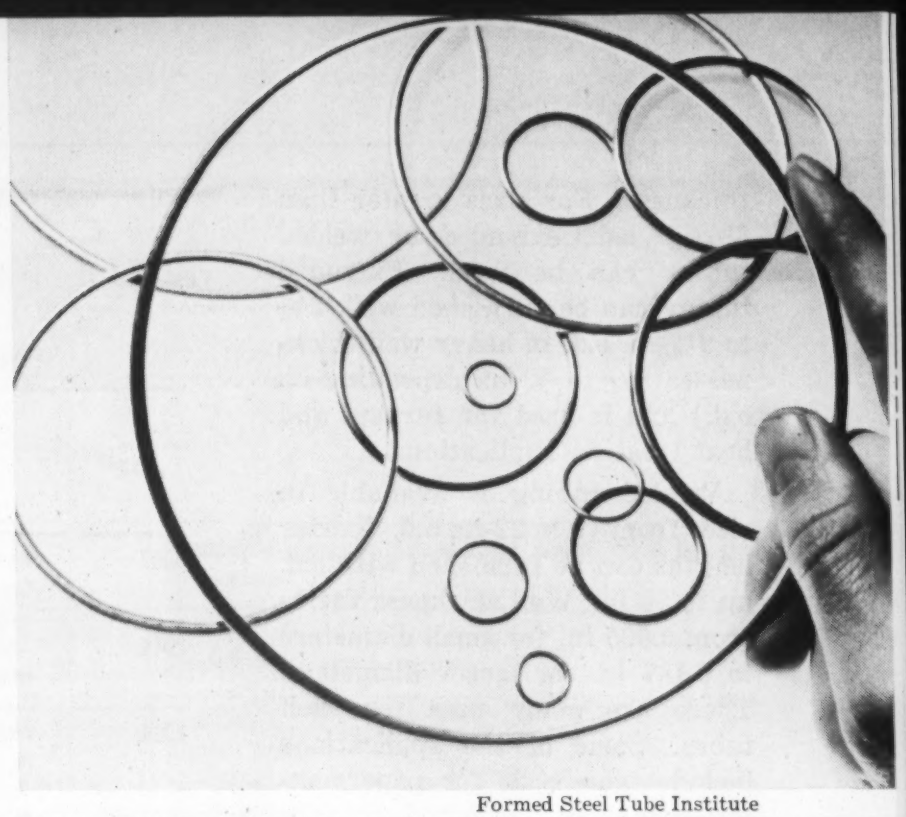
Copper and copper alloy tube can be easily bent and shaped by the common cold and hot working methods. For machining applications free-cutting Muntz metal or high-lead brass is preferred.

There are a wide variety of possible applications, most of which combine mechanical factors with some other property. Besides ornamental uses, there are practical uses involving corrosion resistance or high electrical conduc-



Detroit Transmission Div., General Motors Corp.

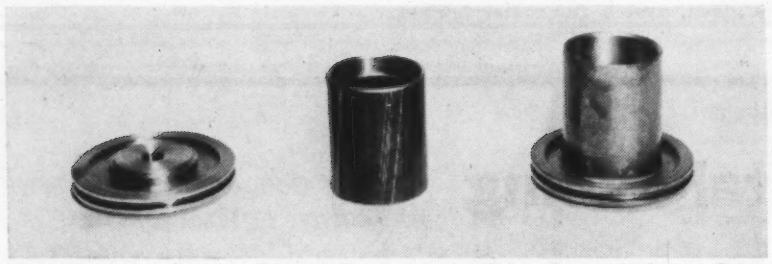
Internal ring gear *for automatic transmissions, formerly a forging, now fabricated from alloy steel tubing and then machined. Cost saving of 25% is reported.*



Formed Steel Tube Institute

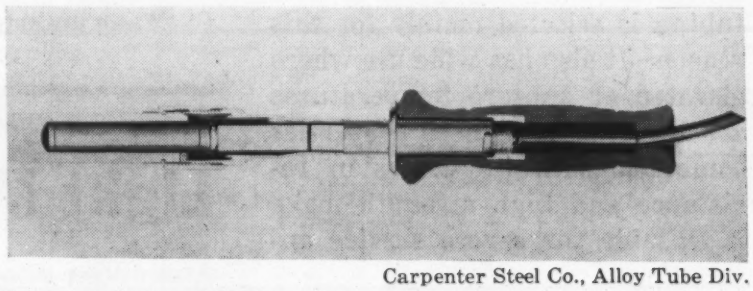
Specialty application *for small diameter tubing is demonstrated by these o-rings fabricated in both carbon and stainless grades of welded steel. Tubing is advantageous because of wide size range available as well as high strength-to-weight ratio and excellent forming properties.*

Some typical uses of mechanical tubing



Detroit Transmission Div., General Motors Corp.

Piston formerly machined *from bar stock was redesigned as disk and carbon steel tubing which are brazed together. Cost saving of 20% is reported.*



Carpenter Steel Co., Alloy Tube Div.

Industrial soldering iron *uses ferritic stainless steel tubing to serve as a jacket for the cartridge heater.*

tivity. The free machining compositions are used for a variety of screw machine products. Corrosion resistance combined with good ductility and strength have made copper alloy tube useful for many products. Aside from applications of particular alloys as listed in the table above, general uses include: plumbing supplies, air pump barrels, pump liners, lighting fixtures, optical instruments, pressure gages, parts for fire extinguishers, railings, door checks and shoelace eyelets.

Nickel and Nickel Alloy Tubing

Nickel and nickel alloy mechanical tubing is produced in seamless and welded forms by much the same methods as those used in the manufacture of ferrous tubes. The principal compositions in which this tubing is commonly available are nickel, Monel, K Monel and Inconel. Besides these, there are several others that serve as specialty tubing. As with copper tube, the major use of nickel tubing is for heat exchangers; such tubing is not considered to be mechanical.

Nickel and nickel alloy cold drawn tubing is available in a large range of sizes and in a variety of shapes. In round seamless tubing, standard o.d. ranges from about ½ to 8⅝ in. and wall thickness from about 0.025 to 0.500 in. Specialty tubing, however, can be supplied in smaller sizes down to 0.010-in. o.d. and 0.0015-in. wall

thickness. For sizes greater than 8⅝-in. o.d., extruded or welded tubing can be used. Extruded tubing can be furnished with 2½ to 9¼-in. o.d. in heavy wall thicknesses (¼ to ⅝ in. depending on o.d.) and is used for furnace and heat treating applications.

Welded tubing is available in sizes from ⅛ to 22-in. o.d. Shorter lengths can be furnished with o.d. up to 30 in. Wall thickness varies from 0.005 in. for small diameters to 0.187 in. for larger diameters. There are many uses for such tubes. Some of the applications include table rolls for papermaking machines, sleeves for large diameter shafts, stems for large valves, and pump liners.

The tolerances attainable in nickel and nickel alloy tubing are in most respects quite similar to those for steel tubes.

The outstanding characteristic of nickel and high nickel alloys is their excellent resistance to a great variety of chemicals, including practically all alkalis and the halogens. Because its cost is relatively high, nickel and nickel alloy tubing is selected mainly for this reason. It also has wide use where elevated or subzero temperatures are involved, and these properties combined with its corrosion resistance and high strength make it suitable for severe service applications.

Nickel and nickel alloy tubing in the correct temper can be readily worked by both hot and cold methods. In general it can be hot worked by a technique similar to that for steel, providing proper attention is given to cleanliness, the nature of the atmosphere, and the use of low sulfur fuels. The hot malleability range varies with the degree of hot work and the alloy composition. These materials in the proper tempers can also be subjected to cold bending, coiling, expanding, rolling, upsetting, welding, slitting, etc. The high nickel materials are not difficult to machine, although different combinations of tooling, speeds, feeds and cutting compounds are required than those used with steels.

Light metal tubing—

PROPERTIES OF EXTRUDED

Type	Condition	Ten Str, 1000 psi		Yld Str, 1000 psi	
		Extr	Drawn	Extr	Drawn
3003	Annealed	14	14	5	5
	Cold Worked	—	17-27	—	12-24
2014	Annealed	24	—	9	—
	Heat Treated	50-68	—	30-58	—
2024	Annealed	25	24	9	8
	Heat Treated	60-70	64	40-48	42
5050	Annealed	—	18	—	16
	Cold Worked	—	25-29	—	20-24
5052	Annealed	—	25	—	10
	Cold Worked	—	34-39	—	26-31
6061	Annealed	14	16	5	5
	Heat Treated	26-28	30-42	16-35	16-35
6062	Annealed	14	16	5	5
	Heat Treated	26-38	30-42	16-35	16-35
6063	Heat Treated	17-32	28-40	10-25	25-35
7075	Annealed	29	—	11	—
	Heat Treated	78-80	—	70-72	—

[a]Minimum expected values for round tubing.
[b]Where two values are given, first is for softer temper.

Light Metal Tubing

Aluminum alloys

Tubing of aluminum alloys is produced either in the extruded or drawn form. All aluminum tubing goes through the extruded stage. It is produced from hollow blooms which are extruded from drilled, pierced or hollow as-cast ingots. Extruded tubing is manufactured to size in extrusion presses, and straightened by stretching or contour rolling. For smaller sizes and closer tolerances than possible in the extruded form, the tubing is further processed by cold drawing to final size. This processing also increases hardness and strength and is used to produce the cold worked tempers of non-heat-treatable alloy tubing.

Though round sections are the most common form, seamless aluminum tubing is also produced in a variety of other shapes, including square, rectangular, oval elliptical, hexagonal and octagonal.

Standard extruded tubing is generally limited in o.d. to 1.25 to 12.250 in.; wall thickness runs from 0.050 to 6 in. Cold drawn tubing is produced in outside diameters as small as 0.125 or as large as 11.5 in.; wall thickness generally varies from 0.014 to 0.500 in., depending on the alloy, temper and size. Diameter and wall thickness tolerances for the standard range of sizes are given in the table at the right.

The table above lists the aluminum alloys commonly furnished in tube form. They are available in a number of different tempers; the table gives the range of val-

properties and tolerances

AND DRAWN ALUMINUM TUBING[a]

Elong (2 in.), %		Hardness[b,c]	Cold Work[b,c]	Machinability[c]	Uses
Extr	Drawn				
25	—	D	A	B	Chemical equipment, storage tanks, piping, other processing applications
—	—	C	C	B	
12	—				
12-6	—	B-A	C-D	A	Aircraft, heavy duty structures
12	—				
10-8	10-16	A	C-D	A	Aircraft structures
—	—	D	A	B	
—	—	C	C	B	Builder's hardware, coiled tubes
—	16	C	A	B	Home appliances, truck and marine applications, hydraulic tubes
—	—	B	C	B	
16	15				
16-10	8-20	C-B	B	B	Heavy duty structures requiring high corrosion resistance
16	15				
16-10	8-20	C-B	B	B	Alternate for 6061
12-8	5	C-B	B-C	B	Architectural applications
10	—				
7	—	A	D	A	Aircraft structures

[c]Ratings are relative to aluminum alloys only. Letter A indicates most favorable property, B less favorable, etc.

ues for each property.

The fabricating properties of aluminum alloy tubing are similar to those of solid stock. Fabricating qualities vary with both alloy and temper, from 3003-0 (the most easily worked) to 7075-T6 (which is used only where the amount of forming is limited to bending over liberal radii). All the alloys are readily machined; relative machinability ratings are given in the table.

Magnesium alloys

Magnesium alloy tubing is produced by extrusion by two methods. In the rod mandrel method a bored billet is used. In the porthole or supported-mandrel method, a solid billet is used. The solid billet is extruded through chambers in the male portion of the die, and the various segments are rewelded under pressure to form a tube.

TOLERANCES FOR EXTRUDED AND DRAWN ALUMINUM TUBING[a]

Diameter, in.[b]	Diameter Tolerance, in.		Wall Thickness, in.	Wall Thickness Tol, in.[c]	
	Drawn	Extruded		Drawn	Extruded[d]
Up to ½	0.003	—	Up to 0.047	—	0.006
½ to 1	0.004	0.010	0.010 to 0.035	0.002	—
1 to 2	0.005	0.012	0.036 to 0.049	0.003	—
2 to 3	0.006	0.015	0.047 to 0.061	—	0.007-0.010
3 to 4	0.008	0.015	0.062 to 0.077	—	0.008-0.012
4 to 5	0.008	0.025	0.050 to 0.083	0.004	—
5 to 6	0.010	0.025	0.078 to 0.124	—	0.009-0.015
6 to 8	0.015	0.035	0.084 to 0.120	0.005	—
8 to 10	0.020	0.045	0.121 to 0.203	0.006	—
10 to 12	0.025	0.055	0.125 to 0.249	—	0.009-0.020
12 to 12.875	—	0.065	0.204 to 0.300	0.008	—
			0.250 to 0.374	—	0.011-0.025
			0.301 to 0.375	0.015	—
			0.375 to 0.499	—	0.015-0.035
			0.376 to 0.500	0.020	—
			0.500 to 0.749	—	0.020-0.045
			0.750 to 0.999	—	0.035-0.055
			1.000 to 1.499	—	0.045-0.065
			1.500 to 2.000	—	0.075

[a]Round tubing. All values are ±.
[b]Range is inclusive of the upper value for drawn tubing, inclusive of the lower value for extruded tubing.
[c]Allowable deviation of mean from specified wall thickness.
[d]Ranges are given because tolerance varies with o.d.

Light metal tubing— properties and tolerances (continued)

PROPERTIES OF EXTRUDED MAGNESIUM TUBING[a]

Type	Ten Str, 1000 psi[c]	Yld Str, 1000 psi[c]	Elong (2 in.), %[c]	Brinell Hardness[c]	Form-ability[d]	D/t Ratio[b] Min	D/t Ratio[b] Max	Remarks and Uses
AZ31B-F	36	24	16	48	A	4	30	General purpose; moderate strength, best formability. Materials handling equipment; printing and photoengraving tubing[e]
AZ61A-F	41	24	15	52	C	4	22	Aircraft purposes; good strength with medium cost. Major use is conveyor rollers; also aircraft components
M1A-F	35	22	9	42	B+	4	32	Most economical; moderate strength, high corrosion resistance. Uses similar to AZ31B; also ladders, furniture components
AZ80A-F	40	23	10	60	D	4	15	High strength, less ductility than ZK60A-T5
ZK60A-F	46	34	12	75	D	4	32	Highest strength with good toughness
ZK60A-T5	50	40	11	82	E	4	32	Chief use at present is missile bodies

[a]Round.
[b]Ratio of tube diameter to wall thickness.
[c]Typical expected values.
[d]A = excellent, B = very good, C = good, D = fair, E = poor.
[e]These are the major uses. Others include: tooling, typewriter platens, aircraft components.

TOLERANCES FOR EXTRUDED MAGNESIUM TUBING[a]

Dia, in.[b]	Mean Dia Tol, in.	Wall Thickness, in.[b] ↓	Mean Wall Thk Tolerance, in. O.D. to 2.99	O.D. 3.00-4.99	O.D. > 5.00
Up to ½	0.008	Up to 0.062	0.007	0.008	0.010
½ to 1	0.010	0.063 to 0.124	0.008	0.010	0.015
1 to 2	0.012	0.125 to 0.249	0.009	0.013	0.020
2 to 4	0.015	0.250 to 0.374	0.011	0.016	0.025
4 to 6	0.025	0.375 to 0.499	0 015	0.021	0.035
6 to 8	0.035	0.500 to 0.749	0.020	0.028	0.045
8 to 10	0.045	0.750 to 0.999	—	0.035	0.055
10 to 12	0.055	1.000 to 1.499	—	0.045	0.065
12 to 12¼	0.065				

[a]Round. All values are ±.
[b]Ranges are not inclusive of higher values.

PROPERTIES OF TITANIUM TUBING[a]

Type	Tensile Strength, 1000 psi	Yield Strength, 1000 psi	Elongation (2 in.), %	General Use
A-40	65	50	28	Max ductility and formability
A-55	80	65	25	General purpose grade
A-70	90	80	20	Higher strength, lower ductility

[a]Typical properties of annealed tubing—seamless or welded.

TOLERANCES FOR TITANIUM TUBING[a]

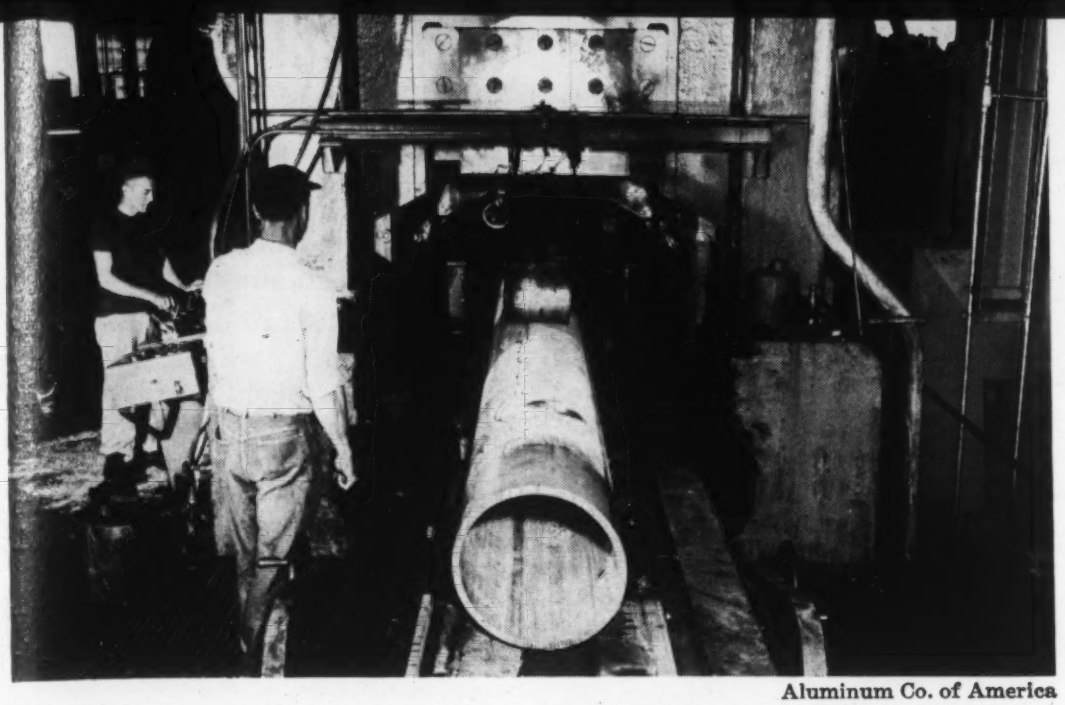
Diameter, in.[b]	Cold Drawn[c] O. D. Tol, in.	Cold Drawn[c] Wall Thk Tol, %	Extruded O. D. Tol, in.	Extruded Wall Thk Tol, %
Up to 1½	0.010[d]	10	—	—
1½ to 3½	0.010	10	—	—
3½ to 5½	0.015	10	0.031	14[e]
5½ to 8	0.030	10	0.047	12.5
8 to 10¾	—	—	0.063	12.5

[a]Round tubing. All values ±.
[b]Range is not inclusive of higher value.
[c]Welded or seamless; also welded with weld area cold worked.
[d]Some producers state 0.005 in. here.
[e]Tolerance is 12.5% if wall thickness is over 0.203 in.

The magnesium alloys available in tube form are listed in a table here along with their properties and characteristics. The mechanical properties vary with the shape and size of the tube; therefore the properties listed are merely typical and approximate. Tables showing tolerances for round magnesium tubing are also given.

Magnesium tubing can be produced in a number of shapes and sizes. Any round, square, rectangular, hexagonal or octagonal shaped tube of uniform wall thickness can be made by extrusion. Round tubing is most widely used and is at present the only standard item available. It is made in diameters from 0.1875 to 12 in., and in a broad range of wall thicknesses. The maximum and minimum ratios of tubing diameter to wall thickness regularly produced are given in the table of properties. In general, wall thickness ranges from 0.05 to 1.50 in.

Magnesium tubing can be formed in much the same way as other common metals, and the same type of equipment is used. Generally the forming operations are performed hot, particularly where bends of small radius are required. Magnesium is the easiest of the common metals to ma-



Aluminum Co. of America

***Extrusion** of a 16-in. aluminum tube on a hydraulic press. This is the largest tubing ever extruded.*

chine, and therefore the tube make very satisfactory screw machine stock.

Like aluminum alloys, magnesium tubing offers a combination of light weight with relatively high strength, and consequently is finding most use in applications where saving of weight is an important factor. Two of the largest applications of magnesium tubing have been rocket launcher tubes and aircraft structures. Other specific applications include hardware, conveyor rolls, furniture, and machinery and parts for the aircraft, textile and transportation industries.

Titanium

Commercially pure grades of titanium tubing are produced in both seamless and welded form. Outstanding among titanium's advantages are light weight, corrosion resistance and high strength. In many respects it is similar to the austenitic stainless steels. It is recommended for use at temperatures from 300 to 750 F under stress.

Alloy titanium tubing is not widely available at present. Attempts to process the existing alloys into tubing have proved difficult, but development work is still continuing. New alloys are being developed which may more successfully take cold reduction by drawing.

Seamless tubes over 3½ in. dia are generally extruded products with a turned or ground surface on the o.d. Smaller sizes are cold drawn by using i.d. mandrels and plugs, and are intermittently vacuum annealed. Welded tubing is first shaped by rolls from bright annealed cold rolled titanium strip. An inert-arc welding head forms a fusion weld without using filler metal or flux. Welded tubing is cold drawn in the same manner as seamless, though larger sizes are often produced by welding and cold working the weld area.

Smaller diameter tubing is produced as both seamless and welded and, where heavy tube walls are required, by tube reducing—a process in which tapered dies rock back and forth over the tube.

Commercially pure titanium does work harden, but it cannot be appreciably hardened by thermal treatment. Thermal treatment is used for relief of stresses set up during cold forming or machining, as well as for full annealing after hot working or severe cold working to restore maximum ductility. Furnace atmospheres should be oxidizing to minimize hydrogen contamination and embrittlement. Standard tempers are: annealed, half hard and hard drawn.

The mechanical properties of titanium are influenced by the purity of the sponge from which it is made, the methods of melting, and by the fabrication procedures employed. The table on p 144 lists typical properties for three major unalloyed grades in which tubing is made. Annealing or stress relieving treatments following working will produce changes in the properties. Hardness values have been omitted because of the difficulty in correlating results obtained by different methods.

Most of the forming and machining operations possible on other metal tubing can be performed on titanium with proper equipment and knowledge. Many operations can be carried out at room temperature. Slow working operations—at greater pressures than required for carbon steel—are preferred. At times it is necessary to heat the dies and work to 500 F or higher. Examples of bending radius limitations at room temperature: A-55, 2t; A-70, 3t.

Sizes of tubing generally range from o.d. of ⅜ to 6 in. with wall thickness from 0.020 to 0.375 in. Some manufacturers supply sizes with o.d. from 6¼ to 10¾ in. and wall thickness from 0.065 to 0.120 in. Extremely small sizes are also available, with o.d. as small as 0.012 in. and wall of 0.002 in.

Titanium tubing is relatively new and applications will grow with experience. Its high corrosion resistance has led to uses in chemical equipment; its high electrical resistivity has been exploited in electrical instruments and equipment; its high strength-to-weight ratio makes it desirable for aircraft applications. Many of these applications are experimental and make use primarily of small diameter tubing to such an extent that for titanium these small sizes cannot properly be considered specialty items. Other uses include: guided missiles and rockets, marine transportation, agricultural equipment, photography and dental instruments.

Specialty Tubing

By specialty tubing we refer primarily to tubing produced for one specific purpose as distinct from regular mechanical tubing which is more generally applicable in industry. In some cases spe-

cialty tubing is made of materials previously discussed, but differs from regular tubing in its dimensional characteristics; in other cases materials other than those described are used to meet special service requirements.

In general, any material which can be satisfactorily cold worked can be manufactured as specialty tubing. A few of the more common ones are discussed briefly below:

Aluminum—Small diameter aluminum tubes are used for instrumentation, refrigeration, air conditioning, television and other purposes. Usual size range in 3003 alloy is from 0.032 to ¾-in. o.d. and from 0.005 to 0.095-in. wall thickness.

A relatively new development is heavy wall tubing, extruded or cold drawn, which is less expensive than bar stock of equal diameter and can save much in machining costs of equipment parts in the aircraft and optical fields. One supplier stocks alloys 2024 and 6061 in sizes ranging from o.d. of 1¼ to 6 in. with wall thickness of 0.219 to 0.750 in.

Copper alloys—Copper and its alloys are used for many small-diameter tubing applications including refrigeration tube and long coils for use in instrument tubing and coaxial cables. These precision-finished seamless tubes generally range from 0.032 to ¾-in. o.d. with wall thickness from 0.005 to 0.095 in. Another product is capillary tube suitable for bulb and bellows assemblies, oil and gasoline gages, and recording thermometers. Sizes range from 0.026 to 0.064-in. i.d.

Beryllium copper, although high in cost, finds a variety of applications where its high strength, high electrical conductivity in the hardened condition, excellent fatigue strength, low drift factor, and good spring qualities can be used to advantage. It can be produced in both welded and seamless tube forms. Some typical applications are contact rolls for business machines, fishing poles and Bourdon springs.

TOLERANCES FOR SMALL DIAMETER TUBING[a]

Diameter, in.[b]	O.D. Tol, in.	I.D. Tol, in.
Up to 3/32	+0.002	-0.002
3/32 to 3/16	+0.003	-0.003
3/16 to ½	+0.004	-0.004
½ to 1½	+0.005	-0.005

[a]Wall thickness tolerance is ±10%. These tolerances are general; suppliers specializing in particular materials or sizes often hold closer tolerances for standard tubing.
[b]Range is not inclusive of higher value.

Nickel alloys—Much tubing for electronic products is made of nickel and several special nickel alloys. For example, three 99% nickel compositions, known as "220," "225" and "330" nickel, are used for hot cathodes, anodes and cold cathodes. Another composition known as "D" nickel is suitable for high temperature applications. In applications where sealing to glass is a requirement, 36% nickel-iron, 42% nickel-iron or 52% nickel-iron can be used. These alloy tubes find use in such things as testing and measuring devices, and special electrical instrument applications such as thermometry and phonograph pick-up arms.

Small diameter nickel and nickel alloy tubes (from o.d. of 0.032 in. with wall thickness of 0.003 in., to 1.00 in. with wall of 0.065 in.) are supplied for surgical instruments, electronic equipment, mandrel tubes for glass manufacture, thermocouple tubes, etc.

Stainless steel—Large diameter (4 to 40 in.), light-wall stainless and high alloy tubing is produced by fusion welding for waste disposal systems in the chemical industry, rolls in the papermaking and dyeing industries, exhaust stacks for corrosive gases, and stock lines for the corn industry. Small diameter tubing ranging from 0.032 to 1.0 in. (wall thickness from 0.003 to 0.065 in.) finds use as capillary tubing.

Very fine tubing—Many alloys are available in fine tubing with o.d. as small as 0.008 in. and walls as thin as 0.0010 in. Aluminum, brass, nickel and stainless steel are the principal metals used. Two important applications are hypodermic tubing of nickel alloy or stainless, and instrument needle pointers of aluminum.

Thin-walled tubing—This is another specialty which has many applications, including instrument springs, flexible metal hose, antennas, and a variety of mechanical parts. Wall thicknesses down to approximately 1% of the o.d. are possible.

Composite tubing—A specialty product which has some mechanical application, composite tubing is used mainly in the pressure tube and piping field. Composite tubing consists of two or more concentric tubes of different metals bonded together. The strong mechanical bond permits the common forming operations to be performed without failure. The combinations, arrangements and thicknesses of the layers in composite tubing are practically unlimited.

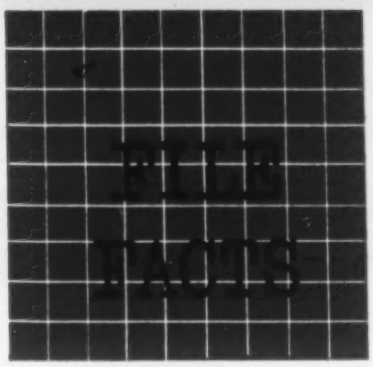
In addition to those mentioned above, specialty tubing can be obtained in many other metals and alloys. Some of these are nickel silver, Armco iron, Incoloy, Nichrome, Advance Alloy (Constantan), and many special ferrous types.

Acknowledgment

The following organizations, through their literature or personal help, supplied much of the information for this manual:

Aluminum Co. of America
American Brass Co.
American Cast Iron Pipe Co.
American Iron & Steel Inst.
American Society for Testing Materials
American Tube Bending Co., Inc.
Babcock and Wilcox Co., Tubular Products Div.
J. Bishop & Co. Platinum Works, Stainless Steel Products Div.
Bridgeport Brass Co.
Brooks & Perkins, Inc.
Carpenter Steel Co., Alloy Tube Div.
Copper and Brass Research Assn.
Dow Chemical Co., Magnesium Div.
Formed Steel Tube Institute
Ohio Seamless Tube Div., Copperweld Steel Co.
Peter A. Frasse & Co., Inc.
International Nickel Co., Inc.
Michigan Seamless Tube Co.
Mueller Brass Co.
Precision Tube Co., Inc.
Reynolds Metals Co.
Republic Steel Corp., Steel and Tubes Div.
Revere Copper and Brass, Inc.
Joseph T. Ryerson & Son, Inc.
Scovill Mfg. Co.
Superior Tube Co.
Titanium Metals Corp. of America
Trent Tube Co.
Tube Reducing Corp.
Uniform Tubes, Inc.
Wolverine Tube Div., Calumet & Hecla, Inc.

Reprints of this Manual are available at 35¢ each until supply is exhausted. See page 236 for complete list of available Manuals. Write for quotations on quantities of 100 or more. Address Reader Service Dept., MATERIALS IN DESIGN ENGINEERING, *430 Park Ave., New York 22, N. Y.*



Properties of Plastics Films—A Materials Data Sheet

	Type →	Rigid Polyvinyl Chloride (incl copolymers)	Nonrigid Polyvinyl Chloride (incl copolymers)	Polyvinylidene Chloride (Saran)	PVC-Nitrile Rubber Blend	Polyvinyl Alcohol	Polyethylene
GENERAL PROPERTIES	ASTM						
Method of Production[a]		Cast, calndr, extr	Cast, calndr, extr	Extr	Cast, calndr, extr	Cast	Calndr, extr
Forms Available		Sheet, rolls, tapes	Sheet, rolls, tapes, tubes	Rolls, tubes	Sheet, rolls, tapes, tubes	Rolls	Sheet, rolls, tapes, tubes
Clarity[c]		Trp, trl, opaque	Trp, trl, opaque	Trp, trl, opaque	Trp, trl, opaque	Trp, trl	Trl, opaque
Min Thickness, in.		0.001	0.0005	0.0005	0.001	0.001	0.00075
Max Width, in.		54	104	40	84	54	144
Area Factor, 1000 sq in./lb/mil[d]		19.5-22.5	20-23	16.3	22.8-23.7	21.6	30
PHYSICAL PROPERTIES							
Specific Gravity	D792	1.36-1.50	1.15-1.50	1.68	1.18-1.35	1.21-1.31	0.92
Ten Str, 1000 psi	D882	6.5-8.5	1-5	7-15	1.5-4.0	6-10	1.6-3.0
Elong, %	D882	5-25	50-500	25-40	250-500	400-600	200-800
Burst Str (Mullen), psi[e]	D774	—	9-20	30-70	—	185-235	48
Tear Str (Elmendorf), gm/mil	D689	20-150	30-1400	30	100-960	500-800	100-300
Fold Endurance[e]	D643	Poor	Good	500,000[g]	Excellent	Good	Good
Heat Seal Temp Range, F[f]		260-400	200-400	285	220-350	300-400	250-375
Water Absorp (24 hr), %	D570	Negligible	Negligible	Negligible	Negligible	> 30	Negligible
Water Vapor Perm, gm/100 sq in./24 hr[e]	E96-53T	0.5 (0.005 in.) to 2.5 (0.001 in.)	0.7 (0.005 in.) to 8.0 (0.001 in.)	0.20	7.0	> 10	1.20-1.40[m]
Gas Perm, cu cm 100 sq in./24 hr [5]							
Oxygen		3 (0.005 in.) to 15 (0.001 in.)	50-30[m]	0.56[m]	—	—	550[m]
Nitrogen		—	—	0.11[m]	—	—	180[m]
Carbon Dioxide		11 (0.005 in.) to 55 (0.001 in.)	250-2000[m]	2.4[m]	—	—	2900[m]
RESISTANCE TO CHEMICALS							
Strong Acids	D543 or D1239	Excellent	Excellent	Excellent[h]	Good	Poor	Excellent[j]
Strong Alkalis		Excellent	Excellent	Good[i]	Good	Poor	Excellent
Greases and Oils		Good	Fair	Excellent	Excellent	Excellent	Fair
Solvents							
Ketone and Ester		Poor	Poor	Fair	Poor	Excellent	Good
Chlorinated		Fair	Fair	Fair	Fair	Excellent	Fair
Hydrocarbon		Excellent	Good	Excellent	Good	Excellent	Fair
PERMANENCE							
Max Cont Svc Temp, F		200-220	150-180	290	200	—	200
Min Svc Temp, F		–70	–50	Good	–40	—	–68
Resistance to Sunlight		Good	Good	Excellent	Fair	Excellent	Good[l]
Dimensional Change, %		Nil	Nil	Nil	Nil	High	Nil
Storage Stability[k]		Excellent	Excellent	Excellent	Excellent	Excellent	Excellent
Flammability (rate of burning)		Self-extinguishing	Slow to self-extinguishing	Self-extinguishing	Slow to self-extinguishing	Slow	Slow

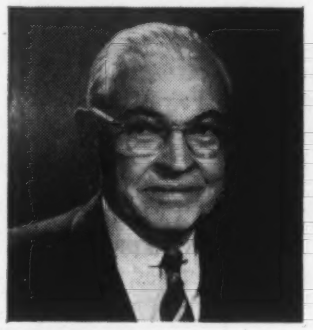
[a]Cast = casting; calndr = calendering; extr = extrusion; block = block process.
[c]Trp = transparent; trl = translucent.
[d]Figures may vary with resin-plasticizer ratio.
[e]Properties particularly dependent on thickness.
[f]Unsupported film cannot be sealed on all types of heat sealers, since adhesion to metal sealer and distortion of film may be encountered.
[g]ASTM D 643, Method A.
[h]Except sulfuric and nitric.
[i]Except ammonium hydroxide.
[j]Except nitric, fuming sulfuric and chlorosulfonic.
[k]Average warehouse conditions: 40-100 F, dry.
[m]0.001-in. film.

(continued on p 151)

For more information, circle No. 547

RB&W FASTENER BRIEFS

RUSSELL, BURDSALL & WARD BOLT AND NUT COMPANY



Technical-ities

By John S. Davey

Fastener coatings

Salt spray testing of various metallic coatings used on fasteners doesn't always give a true picture. In actual service, accelerated test results are not always borne out.

Reason: The tests favor the coatings which can endure continuous moisture and salt atmospheres, whereas some do better under the normal intermittent dry and wet conditions of weathering.

Experience has developed a "scale" of suitability of various coatings for fastener protection.

FOR RUST PROTECTION

Hot galvanizing offers greatest endurance under most conditions. It falls short on highly stressed fasteners.

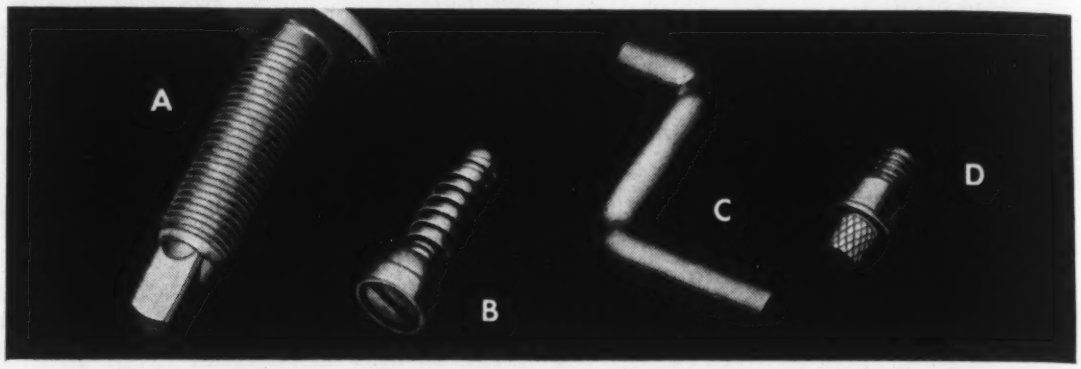
Electrodeposited zinc is next most practical – providing good appearance, controlled tolerance at threads, and ability to take high bolt tensions.

Cadmium plate stands out where salt atmospheres predominate. Not suitable for contact with edibles, it is ruled out for many appliances.

For general applications, the rust prevention of black oxide coatings proves satisfactory. Phosphate coatings, too, offer some degree of protection, but not under severe conditions.

Chromium, plated over copper, should be considered more for its appearance on fasteners rather than protection.

Cold heading creates quality parts the low cost way



No value analysis of product components is really complete without exploring what cold heading machines can do to cut costs. Some examples:

A. ELIMINATE EXTRA OPERATIONS. Leveling screw, formerly made by riveting flat disc to set screw, now emerges as a stronger, single piece from a cold header.

B. ONE PIECE BETTER THAN TWO. Cold headed hose clamp screw has integral flange which, after head is slotted, is forced up to form screwdriver shield. Before, piece was in two parts . . . with screw made on screw machine, and the shield a stamping fitted around head during assembly.

C. FASTER THAN FORGING. Shifter lever is bent into double "L" automatically in bolt header . . . replacing 2-stage forging operation. The header does it at high speed from continuous rod.

D. METAL *FLOWS* TO SHAPE—NO WASTE. No longer cut on screw machine, insert screw for plastic parts costs 40% less. Cold header uses just the amount of metal required. The threading and knurling, too, are done automatically at high speed.

Metal forced to cold flow into shape results not only in savings but also in stronger parts. With uncut flow lines, the piece is better able to withstand stress concentrations.

For an expert opinion on parts you now use, check with Russell, Burdsall & Ward Bolt and Nut Company, Port Chester, New York.

Plants at: Port Chester, N. Y.; Coraopolis, Pa.; Rock Falls, Ill.; Los Angeles, Calif. Additional sales offices at: Ardmore (Phila.), Pa.; Pittsburgh; Detroit; Chicago; Dallas; San Francisco.

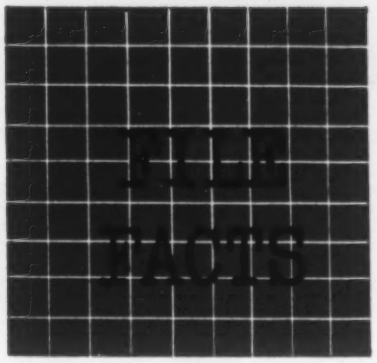
12-point fasteners cut wrench clearance space

Double hex RB&W bolts and nuts measure smaller across their points than single hex fasteners. Used with an *external* socket wrench, they permit optimum driving torque to be applied.

Thus, while permitting design of more compact assemblies, these fasteners also assure proper preloading for stronger connections.

Available with plain flange, or SPIN-LOCK design which incorporates teeth that embed upon tightening and resist loosening under vibration or temperature changes.

For more information, turn to Reader Service card, circle No. 486

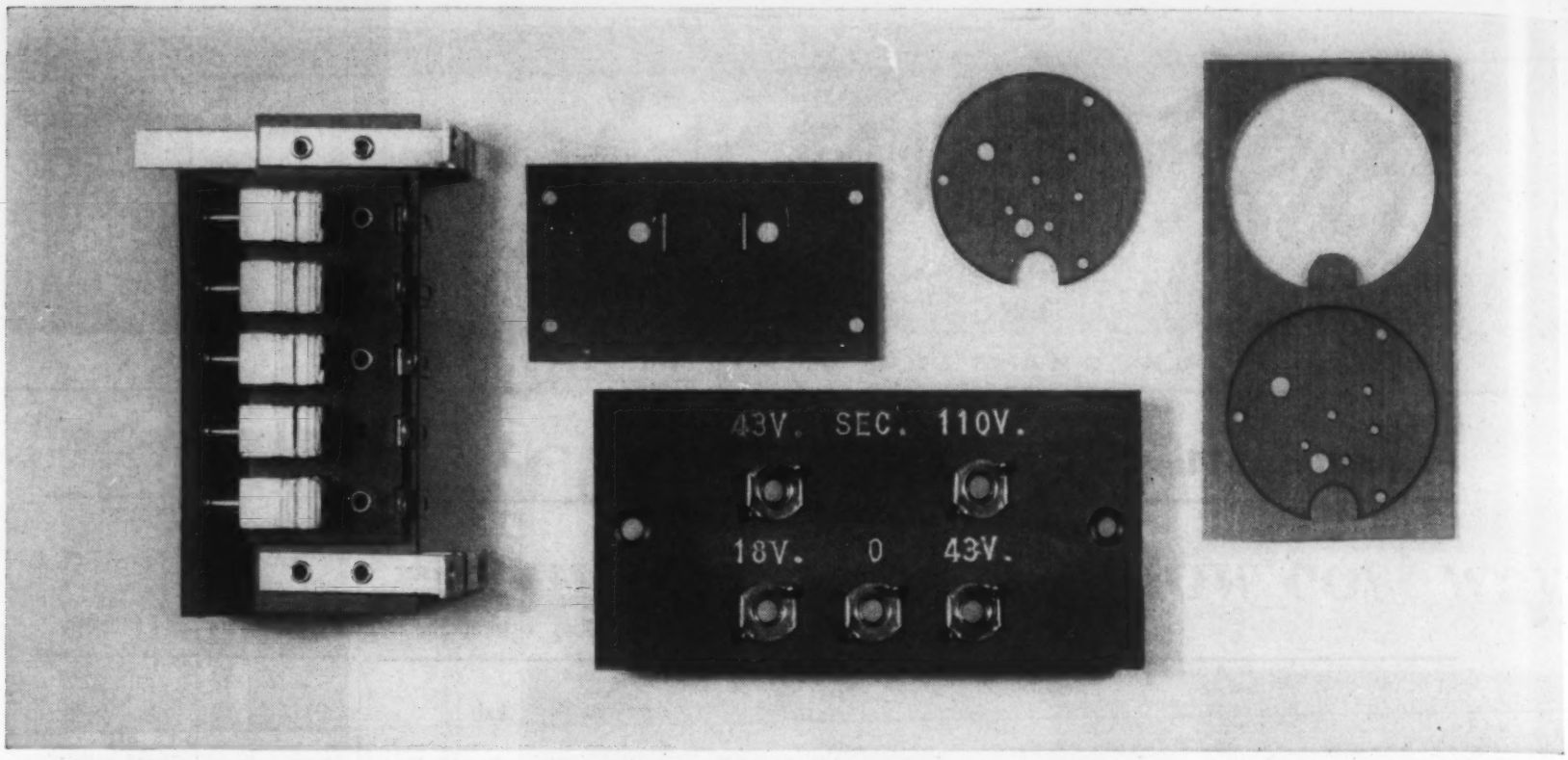


Properties of Plastics Films—continued

Type ➡		Polytetra-fluoro-ethylene	Polytri-fluoromono-chloro-ethylene	Polystyrene (oriented)	Polyester (polyethylene terephthalate)	Rubber Hydrochloride	Ethyl Cellulose
GENERAL PROPERTIES	ASTM						
Method of Production[a]	.....	Block	Extr	Extr	Extr	Cast	Cast, block, extr
Forms Available	.....	Sheet, tapes	Sheet, tubes	Sheet, rolls	Sheet, rolls	Sheet, rolls, tapes	Sheet, rolls, tapes
Clarity[c]	.....	Trp	Trp, trl	Trp, trl, opaque	Trp, opaque	Trp, trl, opaque	Trp
Min Thickness, in.	.....	0.002	0.002	0.001	0.00025	0.0004	0.003
Max Width, in.	.....	12	20	40	55	60	30
Area Factor, 1000 sq in./lb/mil[d]	.....	13	12	26.1	20	24	24
PHYSICAL PROPERTIES							
Specific Gravity	D792	2.15	2.11	1.05-1.07	1.39	1.12-1.15	1.14-1.16
Ten Str, 1000 psi	D882	2-3	6.3-6.6	7-12	17-28	5-6	6-10
Elong, %	D882	200-250	90-200	3-10	70-130[m]	350-500	20-35
Burst Str (Mullen), psi[e]	D774	—	42	30-60	45[m]	—	30-86
Tear Str (Elmendorf), gm/mil	D689	—	200-350	2-8	18	1000-1500	2-15
Fold Endurance[e]	D643	—	—	—	Excellent	10^4-10^6	2700
Heat Seal Range, F[f]	.....	Not heat sealable	415-450	220-300	490	225-350	—
Water Absorp (24 hr), %	D570	None	None	0.04-0.06	Negligible	Negligible	Low
Water Vapor Perm, gm/100 sq in./24 hr[e]	E96-53T	—	0.00	6.2	1.8[m]	0.5-15.5	10-50
Gas Perm, cu cm/100 sq in./24 hr[e]							
Oxygen	.....	—	0.76[m]	213	5.7[m]	2-405	—
Nitrogen	.....	—	5.5[m]	42	0.9[m]	—	—
Carbon Dioxide	.....	—	8.0[m]	926	17.5[m]	36-2616	—
RESISTANCE TO CHEMICALS							
Strong Acids	D543 or D1239	Excellent	Excellent	Good	Excellent	Good	Poor
Strong Alkalis	.....	Excellent	Excellent	Excellent	Excellent	Good	Excellent
Greases and Oils	.....	Excellent	Excellent	Good	Excellent	Excellent	Good
Solvents							
Ketone and Ester	.....	Excellent	Excellent	Poor	Excellent	Fair	Poor
Chlorinated	.....	Excellent	Excellent	Good	Excellent	Fair	Poor
Hydrocarbon	.....	Excellent	Excellent	Good	Excellent	Excellent	Fair
PERMANENCE							
Max Cont Svc Temp, F	.....	565-585	300-395	160-180	490	205	210-275
Min Svc Temp, F	.....	-90	-120	Good	-80	-20	-75
Resistance to Sunlight	.....	Excellent	Excellent	Fair	Fair	Fair	Good
Dimensional Change, %	.....	Nil	Nil	Nil	Nil	Slight	Slight
Storage Stability[k]	.....	Excellent	Excellent	Good	Excellent	Good	Excellent
Flammability (rate of burning)	.....	Nil	Nil	Slow	Self-extinguishing	Self-extinguishing	Slow

[a]Cast = casting; calndr = calendering; extr = extrusion; block = block process.
[c]Trp = transparent; trl = translucent.
[d]Figures may vary with resin-plasticizer ratio.
[e]Properties particularly dependent on thickness.
[f]Unsupported film cannot be sealed on all types of heat sealers, since adhesion to metal sealer and distortion of film may be encountered.
[k]Average warehouse conditions: 40-100 F, dry.
[m]0.001-in. film.

(continued on p 153)



LEADING MANUFACTURERS USE VULCOID. For a punched timer-switch part that operates in oil; for arc chutes in circuit breakers; for the insulation and structural part of an auto-headlight dimmer switch; for a formed electrical switch part carrying 110-volt 60-cycle current; for a mass-produced, 110-volt light-socket part—for these and many more Underwriters-approved parts, CDF Vulcoid is an effective, economical insulation material—good where neither plain fibre nor plain phenolic laminate would suffice.

Fibre gives it high arc-resistance . . .
Aniline resin gives it moisture-resistance

CDF VULCOID

resin-impregnated vulcanized fibre

Vulcoid® is *different.* To the electrical properties of vulcanized fibre we've added the low moisture-absorption of an aniline-type resin with an unusual affinity for cellulose fibers—*all at low cost.* Excellent moisture-resistance (two to four times that of plain vulcanized fibre) helps stabilize Vulcoid's excellent electrical insulating characteristics. Its low cost makes Vulcoid a fine production material for applications of moderate electrical requirements.

Underwriters' approval. Vulcoid is approved by Underwriters' Laboratories as a material for the insulation of current-carrying parts in electrical equipment. It carries the distinctive red and blue thread marking of such materials.

Easy to work. Like vulcanized fibre, Vulcoid is readily drawn or formed into permanent shapes, punched, machined (see illustration above) at low cost. CDF fabrication facilities can give you production quantities of Vulcoid parts to your specifications.

Learn all the advantages of designing around low-cost CDF Vulcoid parts such as arc-deflector spacers, transformer and motor lead bushings, circuit-breaker and transformer barriers, knife-switch guides, transformer coil separators, instrument and contact panels, baseboard receptacles, etc. Ask your CDF man or write for new technical bulletin.

CONTINENTAL-DIAMOND FIBRE

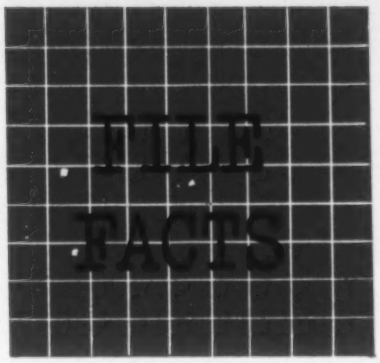
A SUBSIDIARY OF THE Budd COMPANY • NEWARK 25, DEL.

COMPARATIVE PROPERTIES

Property	Percent Normal Deviation	Commercial Vulcanized Fibre 1/16"	Paper Base (XX) Phenolic 1/16"	VULCOID 1/16"	1/8"	1/4"	1/2"	3/4"	1"
Arc Resistance, seconds	±25	140	4	110	110	110	110	110	110
Specific Gravity	±10	1.25	1.35	1.35	1.35	1.35	1.30	1.20	1.10
Moisture Absorption, % 24 hours	±25	60	1.4	30	15	6	4	4	4 8
Tensile Strength, thousands of psi. —MD CD	±25	11	12 10	12.5 7.5	12 7.5	11 7	9 6.5	8.5 6	5.5 12
Flexural Strength, thousands of psi. —MD CD	±25	16	19 17	24 19	23 17	20 16	16 13	14 11	9 60
Shearing Strength, thousands of psi. —MD CD	±25	8.5 8	14 12	14 12	12.5 11	12 10			
Compressive Strength, flatwise thousands of psi.	±20	25	34	36	36	36			
Izod Impact Strength MD (Edgewise) Ft. lbs. per inch of notch	±20	2.0	0.50*	1.2	1.2	1.2	1.2		
Dielectric Strength, VPM Perpendicular to surface	±20	175	700	475	425	275	170	100	

NOTE: ASTM test methods used for Specific Gravity, Moisture Absorption, Arc Resistance, Tensile, Flexural, Compressive, and Dielectric Strength.

For more information, turn to Reader Service card, circle No. 513



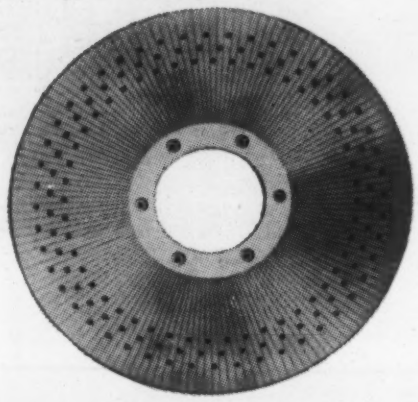
Properties of Plastics Films—concluded

Type →		Cellophane		Cellulose			
		Plain	Coated	Acetate[m]	Triacetate (42.5-44% acetyl)	Acetate Butyrate[m]	Nitrate
GENERAL PROPERTIES	ASTM						
Method of Production[a]		Extr	Extr	Extr, cast	Cast	Extr, cast	Cast, block
Forms Available		Sheet, rolls, tapes	Sheet, rolls	Sheet, rolls, tapes, tubes	Sheet, rolls	Sheet, rolls	Sheet, rolls
Clarity[c]		Trp	Trp	Trp, trl, opaque	Trp	Trp, opaque	Trp, trl, opaque
Min Thickness, in.		0.0009	0.0009	0.0005	0.003	0.0009	0.0005
Max Width, in.		60	60	60	45	40	50
Area Factor, 1000 sq in./lb/mil[d]		21.5	19.5	22	21.7	23.3	20
PHYSICAL PROPERTIES							
Specific Gravity	D792	1.45	1.40-1.55	1.25-1.35	1.28	1.16-1.18	1.42-1.46
Ten Str, 1000 psi	D882	8-19	7-16	9-14	9-11	6-9	10-11
Elong, %	D882	15-25	15-50	15-35	25-35	50-70	30-40
Burst Str (Mullen), psi[e]	D774	—	—	30-80	100-150	40-75	40-50
Tear Str (Elmendorf), gm/mil	D689	2-10	2-15	2-15	10-15	4-16	—
Fold Endurance[e]	D643	7000-22,000	—	1500-2000[n]	200-300[n]	900-1300[n]	50-250[g]
Heat Sealing Range, F[f]		Not heat sealable	200-350	400-500	—	—	—
Water Absorp (24 hr), %	D570	High	High	Low	Low	Low	Low
Water Vapor Perm, gm/100 sq in./24 hr[e]	E96-53T	High	0.2-1.0	10-40	10	60	—
Gas Perm, cu cm/100 sq in./24 hr[e]							
Oxygen		—	Low	3-6	—	—	—
Nitrogen		—	Low	—	—	—	—
Carbon Dioxide		—	Low	12-31	—	—	—
RESISTANCE TO CHEMICALS							
Strong Acids	D543 or D1239	Poor	Poor	Poor	Poor	Poor	Good
Strong Alkalis		Poor	Poor	Poor	Poor	Poor	Fair
Greases and Oils		Excellent	Good[l]	Good	Good	Fair	Fair
Solvents							
Ketone and Ester		Excellent	Poor[l]	Poor	Poor	Poor	Poor
Chlorinated		Excellent	Excellent	Poor	Poor	Poor	Fair
Hydrocarbon		Excellent	Fair	Good	Good	Good	Fair
PERMANENCE							
Max Cont Svc Temp, F		375	300-375	250-300	300-400	200-250	140
Min Svc Temp, F		0	0	–25	–25	–25	—
Resistance to Sunlight		Good	Good	Good	Good	Good	Poor
Dimensional Change, %		3-5	2-5	0.2-0.8	0.4	0.3	Nil
Storage Stability[k]		Good	Good	Excellent	Excellent	Excellent	Fair
Flammability (rate of burning)		Fast	Fast	Slow,70-100[b]	Self-extinguishing	Slow, 50-80[b]	Fast

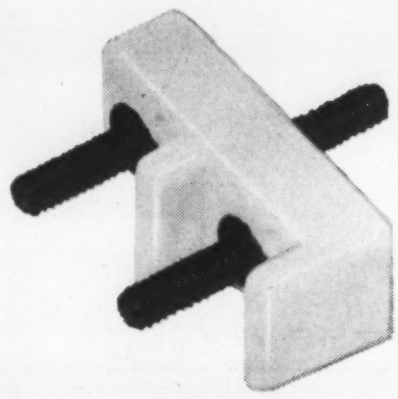
[a]Cast = casting; calndr = calendering; extr = extrusion; block = block process.
[b]ASTM D 568.
[c]Trp = transparent; trl = translucent.
[d]Figures may vary with resin-plasticizer ratio.
[e]Properties particularly dependent on thickness.
[f]Unsupported film cannot be sealed on all types of heat sealers, since adhesion to metal sealer and distortion of film may be encountered.
[g]ASTM D 643, Method A.
[k]Average warehouse conditions: 40-100 F, dry.
[l]Coating attacked.
[n]ASTM D 643, Method B.

Source: *Technical Data on Plastics*, published by Manufacturing Chemists Assn., Inc.

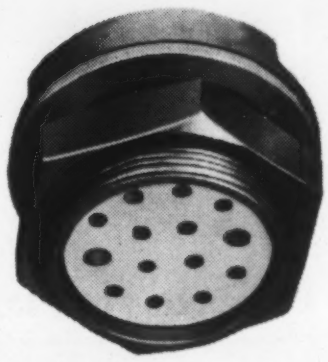
DESIGN ACHIEVEMENTS WITH **SUPRAMICA*** CERAMOPLASTICS



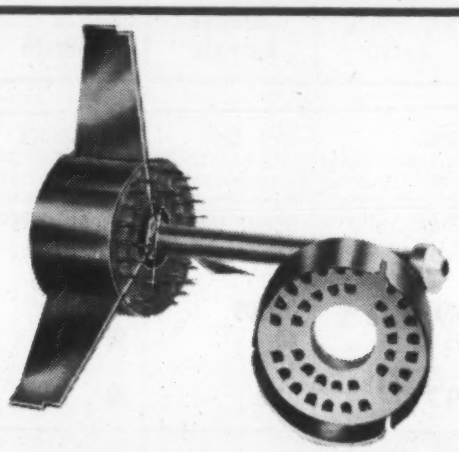
OPTICALLY FLAT CAPACITY COMMUTATOR PLATE|SUPRAMICA 500



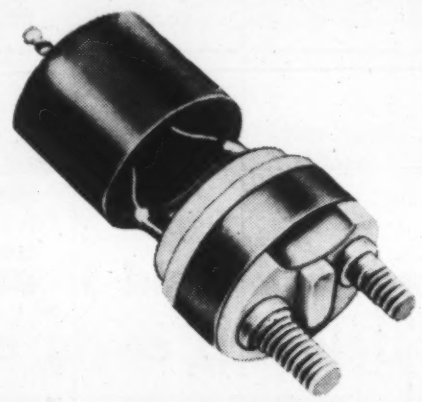
HIGH-TEMPERATURE AIRCRAFT TERMINAL BLOCK|SUPRAMICA 560



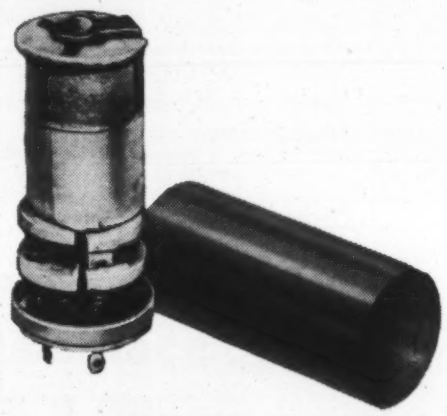
HIGH-TEMPERATURE A-N CONNECTOR |SUPRAMICA 560



RADIATION RESISTANT AIRCRAFT ENGINE CONNECTOR|SUPRAMICA 555



HIGH TEMPERATURE FIREWALL THERMOCOUPLE|SUPRAMICA 555



ORGANIC VAPOR FREE HIGH TEMPERATURE SEALED RELAY|SUPRAMICA 555

HIGH TEMPERATURE ceramoplastic INSULATION

SUPRAMICA ceramoplastics provide broader design scope for product engineers

Increased thermal endurance . . . total, permanent dimensional stability . . . better electrical properties . . . lower density and improved machineability of SUPRAMICA ceramoplastics bridge the design gap between organic plastics and conventional ceramics. The world's most nearly perfect insulation, SUPRAMICA ceramoplastics allow product engineers to meet the requirements of today's thermal problems.

There is no possibility of shrinkage, growth or age polymerization since the materials are completely inorganic, made with SYNTHAMICA* synthetic mica. Metal inserts molded in SUPRAMICA ceramoplastics cannot loosen during thermal cycling because coefficients of expansion are closely matched. Other desirable properties are high dielectric strength, radiation and arc resistance, low electrical loss, resistance to moisture, oil and organic solvents. In thousands of military and critical industrial applications, SUPRAMICA ceramoplastics are contributing to better, safer, more reliable operation of electrical and electronic equipment.

Write for complete technical information.

SUPRAMICA* 560 — for temperatures over 500°C (932°F)

SUPRAMICA* 555 — for temperatures up to 650°F

SUPRAMICA* 500 — sheet and rod material for machining

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WORLD'S LARGEST MANUFACTURER OF GLASS-BONDED MICA AND CERAMOPLASTIC PRODUCTS.

For more information, turn to Reader Service card, circle No. 557

What's new IN MATERIALS

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One drop *of Eastman's new adhesive is placed between two 2-in. steel rods and allowed to set.*

30 min later *the bond formed from the one drop of adhesive supports a load totaling 5000 lb.*

High strength, heat resistance offered by . . .

Three New Adhesives for Steel, Other Materials

■ Development of three new adhesives—a modified cyanoacrylate monomer that bonds most materials together within minutes, and two epoxy adhesives that withstand temperatures up to 500 F—has been announced by Eastman Chemical Products, Inc. (a division of Eastman Kodak Co.), Kingsport, Tenn., and Rubber & Asbestos Corp., 225 Belleville Ave., Bloomfield, N. J.

Eastman's adhesive

The bond formed from one drop of Eastman's adhesive, when applied to one end of a 2-in. steel rod and pressed to a similar rod, is said to support a 5000-lb automobile within 30 min after application (see photo).

Discovered accidentally in Eastman's laboratories in Kingsport, the adhesive, called 910 and currently available in limited quantities, is said to form strong bonds between glass and glass in 10 to 15 sec, between aluminum and aluminum in 45 to 60 sec, between steel and Neoprene rubber in 5 sec, and between wood and wood in 3 to 5 min. According to the producer, the most unusual property of the adhesive is "the rapidity with which it forms strong bonds."

Potential uses — The producer believes the adhesive should find use in the following areas:

1. In bonding applications where extreme speed of setting and curing are needed.
2. In products where unlike materials cannot be bonded by conventional adhesives.
3. In small confines where high bonding strengths are required.

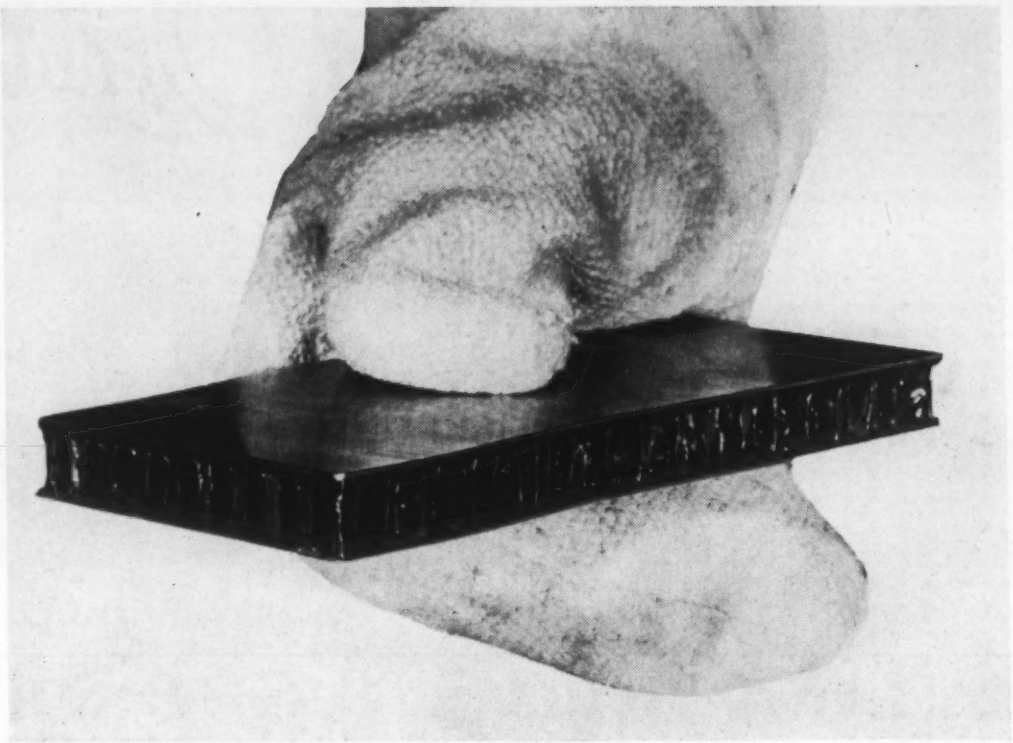
According to the producer, tests have shown 910 adhesive forms bonds with almost every kind of material. Some of the more common materials which the adhesive will bond are wood, glass, metal, rubber, plastics, cork, felt, leather, cardboard and porcelain. The adhesive is claimed not only to bond these materials to themselves but also to bond many of them to each other. For example, very strong bonds are obtained between wood and metal, glass and metal, and plastics and rubber.

The adhesive works best when the bonding surfaces are thoroughly cleaned and dried prior to application. In most cases, no extensive pretreatment is necessary other than removing all loose dirt, grease and foreign matter from the bonding surfaces.

Properties—The strength of a given bond depends largely upon the nature of the material to be bonded and the care used in preparing the bond. In bonding steel to steel, for example, it has been found that the ultimate bond tensile strength (5000 psi) is not reached until after a 48-hr room temperature cure. The shear strength of a steel-to-steel bond is 3800 psi after aging 24 hr at room temperature. The same steel-to-steel bond has a shear strength of about 4100 psi after aging one

Eastman's 910 Based on Cyanoacrylate

Eastman Chemical scientists say that Adhesive 910 is a cyanoacrylate monomer modified with a thickening agent and a plasticizer. It requires no heat, excessive pressure, catalyst or solvent evaporation to effect a bond. When the monomer is pressed into a thin film between two surfaces, a polymerization reaction takes place without appreciable change in volume. This property, says the producer, probably accounts for the strong bonds formed with plastics, ferrous and nonferrous metals, and natural and synthetic rubbers.



Continuous exposure *to temperatures up to 500 F does not affect adhesive bond in stainless steel sandwich construction.*

week at room temperature.

Tests show the adhesive holds well at temperatures from 0 to about 180 F; even short exposures for 24 hr at temperatures of 210 F do not greatly affect the bond. However, prolonged exposures to temperatures much above 180 F will permanently break down the bond.

Generally, the new adhesive has good solvent resistance, especially in alcohol, benzene and acetone. Laboratory tests show that the adhesive is only slightly resistant to weak alkaline and acid solutions and warm water. The adhesive is not resistant at all to steam or combinations of high humidity and high temperatures.

Handling—According to the producer, 910 adhesive is a very reactive compound and contact with any alkaline substance or water should be avoided. With proper care, the normal useful shelf life of the adhesive is between six months and a year. Care should be taken in handling the adhesive, since, if spilled on skin or clothing, it will produce a solid film which is very difficult to remove. Spillage on the hands, for example, may result in temporary bonding together of the fingers. Preliminary toxicity tests indicate that the adhesive is a relatively nontoxic substance.

PROPERTIES OF 910 ADHESIVE

Flash Point, F	180
Brookfield Viscosity, cps	100
Density, lb/gal	9.25
Softening Point, F	330
Dielectric Constant	3.34
Dissipation Factor	2.02

Epoxies for 500 F

Rubber & Asbestos Corp.'s two adhesives are designed especially for the bonding of stainless steel parts that must operate continuously at temperatures up to 500 F. Both adhesives are modified epoxies and are supplied as tapes.

One adhesive, called Plymaster 1020, is used for stainless steel metal-to-metal bonding and is supplied as a tape of 20-mil thickness. The other adhesive, called Plymaster 2040, is used for stainless steel honeycomb sandwich constructions and is supplied as a tape of 40-mil thickness with a liquid primer called Bondmaster M 605.

Uses—The two adhesives are said to be particularly useful for aircraft and missiles, since they maintain good strength throughout prolonged high temperature service. Both adhesives are said to be adaptable to bonding techniques and equipment currently in use in the aircraft industry.

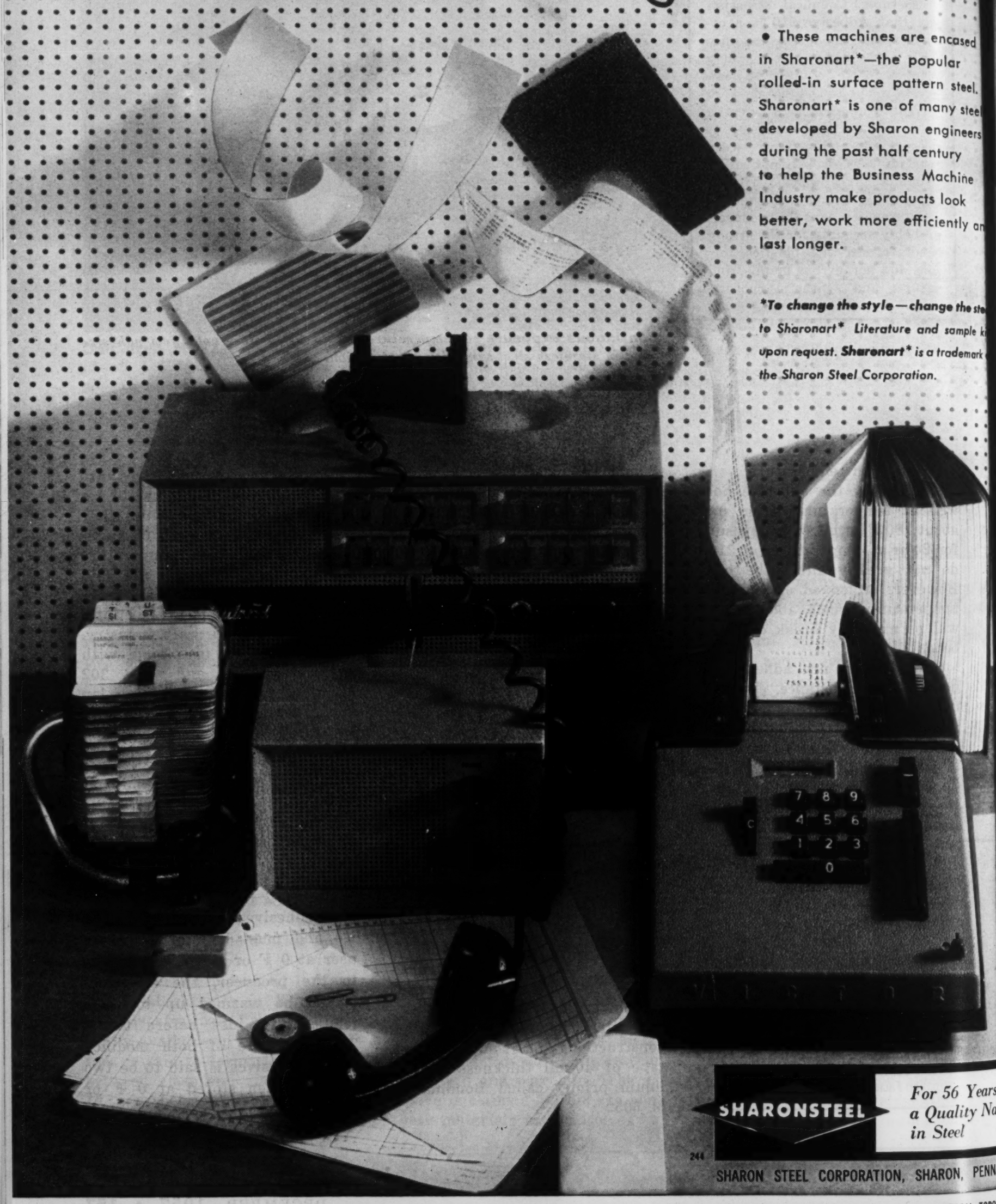
Properties—In tests made with Plymaster 1020 and type 302 stainless steel, the following lap shear strength values were obtained:

1. 1750 psi, unaged.
2. 1500 psi, aged 10 min at 455 F.
3. 1400 psi, aged 200 hr at 455 F.
4. 800 psi, aged 400 hr at 455 F.

Handling—Plymaster 1020 and 2040 adhesives are shipped in dry ice and must be stored by the user at 0 F or lower. According to the producer, the adhesives should be warmed up to room temperature just before using. The shelf life of both modified epoxy adhesives is said to be two months when stored at 0 F or below.

IN BUSINESS MACHINES, TOO,

Sharonsteel Quality STANDS OUT



• These machines are encased in Sharonart*—the popular rolled-in surface pattern steel. Sharonart* is one of many steels developed by Sharon engineers during the past half century to help the Business Machine Industry make products look better, work more efficiently and last longer.

To change the style—change the steel to Sharonart* Literature and sample kit upon request. **Sharonart* is a trademark of the Sharon Steel Corporation.*

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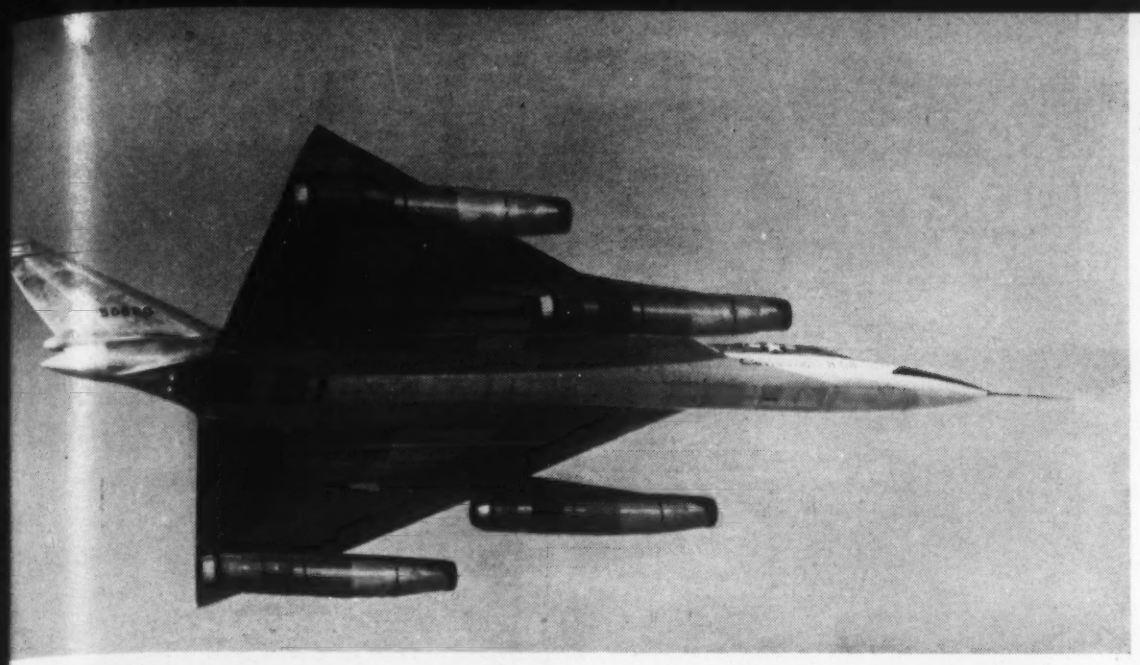


***X2020 aluminum alloy** is expected to make possible the use of aluminum in supersonic bombers similar to one shown here.*

Lithium Improves Properties in Aluminum Alloy

■ Significantly improved properties in a new aluminum alloy are said to result from the first successful use of lithium as an alloying addition. The new alloy, designated X2020 and developed by Aluminum Co. of America, is claimed to offer the following advantages over conventional aluminium alloys:

1. Modulus of elasticity is 8% higher.
2. The alloy is 3% lighter.
3. High strength is maintained at temperatures as high as 400 F.

According to Alcoa, it is the lithium addition which is responsible for the alloy's performance. However, the company declines to explain further, pointing out only that "numerous obstacles to melting and casting a sound ingot had to be overcome . . . but all mill products . . . lend themselves to standard fabrication processes employed by the aircraft industry." Composition of the new alloy has also been withheld.

Chief significance of the alloy seems to be its high temperature superiority over other aluminum alloys (see table). Conventional aluminum alloys lose physical properties at about 250-350 F. For this reason, titanium and stainless steel are being used extensively for airframe structures of jet planes. However, both titanium and stainless add considerably to cost and weight, and Alcoa expects the X2020 alloy to find extensive use in aircraft operating at speeds in the range of 1600 mph.

Samples of the alloy are presently being studied and evaluated by the Air Force, the Navy's Bureau of Aeronautics and several aircraft companies. Alcoa expects to produce the material commercially as soon as performance data have been compiled.

PHYSICAL PROPERTIES OF X2020

Specific Gravity	2.71
Elec Cond (68 F), % IACS	21
Ther Cond, Btu/hr/sq ft/°F/ft	50.82
Coef of Ther Exp, per °F	12.6
Modulus of Elasticity, 1000 psi	
Tension	11,100
Compression	11,400

HIGH TEMPERATURE PROPERTIES OF X2020—A COMPARISON WITH TWO OTHER ALUMINUM ALLOYS[a]

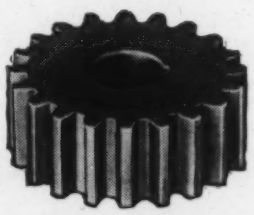
Temp and Time ↓	X2020-T6			2014-T6			7075-T6		
	Ten Str	Yld Str	Elong	Ten Str	Yld Str	Elong	Ten Str	Yld Str	Elong
Room Temp	**86**	**79**	**6**	70	60	13	82	72	11
300 F									
½ Hr	**73**	**70**	**8**	59	51	13	57	51	20
1000 Hr	**70**	**68**	**9**	56	51	14	32	29	35
400 F									
½ Hr	**61**	**57**	**7**	46	43	13	38	34	20
1000 Hr	**31**	**27**	**20**	23	18	30	15	13	50
500 F									
½ Hr	**33**	**32**	**12**	28	25	18	16	14	35
1000 Hr	**19**	**16**	**31**	12	10	40	11	9	60

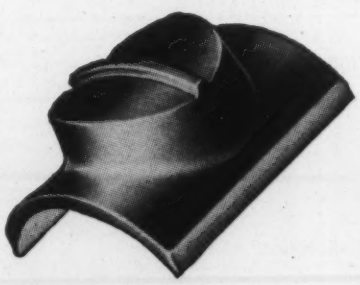
[a]Tensile and yield strengths are given in 1000 psi; elongation is given in percent.

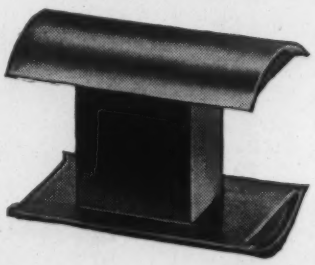
For more information, circle No. 517

This do-it-yourself test proves

RESISTOX® Metal Powders are more stable, resist oxidation 5 to 10 times longer!







This test proves that the Resistox Process gives Glidden Metal Powders more stability through greater resistance to oxidation. You can store Glidden Resistox Metal Powders over long periods of time without fear of oxidation. And you can speed up production of metal parts, with less material-waste and die-wear, greatly improved finish, appearance, and performance characteristics.

In an open container, place a sample of Resistox copper or lead powder. In another, a like amount of an ordinary metal powder of the same type. Then wait . . . 3 days in hot humid weather, 2 weeks in cool dry weather. The striking difference in appearance that results (oxidation causes the ordinary metal powder to change color rapidly) will show comparative resistance to oxidation, prove superiority of Resistox Metal Powder.

Write for your free test-sample of Glidden Resistox Metal Powder (specify lead or copper) and complete information on these additional Glidden products: Cuprous Oxide, Cupric Oxide and Cubond (Copper Brazing Paste).

THE GLIDDEN COMPANY

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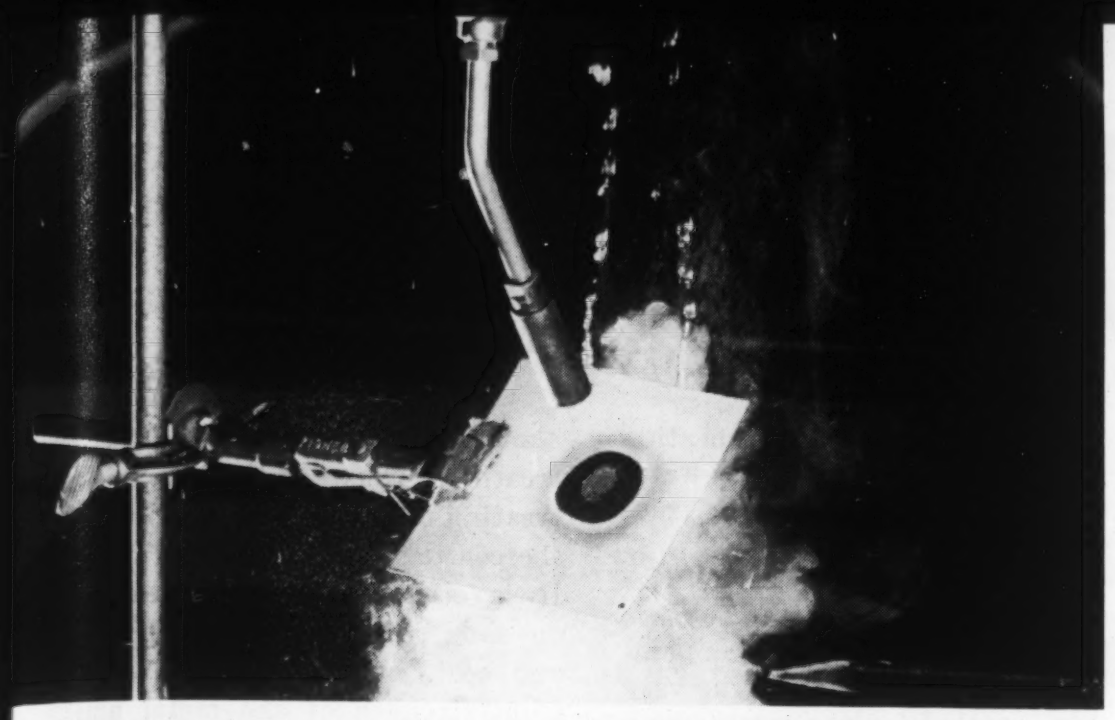


Hot flame test: *A hot flame (1700-1800 F) is applied to one side of a ceramic coating while a stream of cold water is applied to the other side. The shock produced by these temperature extremes does not affect the coating (black area in center of coating is carbon which can be scrubbed off).*

Bend test: *Ceramic coated aluminum sheet can be bent to a 90-deg angle without cracking the coating.*

Developed for aluminum alloys . . .

Lithium Type Ceramic Coatings Resist Prolonged Heat at 1350 F

■ Aluminum alloys coated with newly developed lithium type ceramic coatings can withstand prolonged heat at 1300 to 1350 F without collapsing, according to Dr. Paul A. Huppert, Gulton Industries, Inc., 212 Durham Ave., Metuchen, N. J. The ceramic coatings—lithium chromate, lithium borosilicate and lithium fluoride type compounds— are applied to aluminum by a process developed by Dr. Huppert. Previous attempts to coat aluminum alloys, he says, have resulted in blistering, bubbling, brittleness and excessive warpage of the coatings. Not yet commercially available, the coatings are the result of a research project co-sponsored by Gulton Industries and Lithium Corp. of America.

Applications

Since the structural aluminum alloys begin to lose their strength long before they reach their melting points (1250 to 1375 F), aircraft manufacturers have been turning to stainless steel and other alloys for use as aircraft skins. Steel, however, weighs considerably more than aluminum and greatly adds to the weight of a plane. Dr. Huppert says ". . . structural aluminum alloys in sheets, coated on both sides with the new ceramic coatings, are one-third the weight of comparable sheets of steel and retain their strength for use as aircraft skins at the supersonic temperature range of 300 to 700 F."

New aluminum alloys are being developed that are said to retain their tensile strength at higher temperatures than presently available alloys (see p 159). According to Dr. Huppert, "ceramic coatings for these new alloys may result in achieving our goal of maintaining high tensile strength at elevated temperatures."

How coatings perform

Heat resistant and insulating properties of the coatings were demonstrated with the following tests:

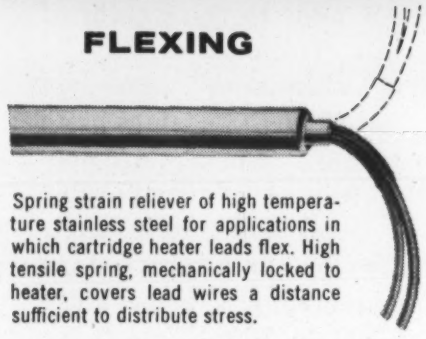
1. Ceramic coated aluminum specimens were subjected to a hot flame for 90 to 120 min. The temperature of the flame measured 1700-1800 F at the surface of the coating. The test showed that the ceramic coated sample was not damaged by the hot flame. A similar test conducted on an uncoated aluminum specimen showed that the hot flame burned a hole in the sample in about 30 sec.

2. A coated sample was placed in an electric furnace and heated to 1500 F. After 2 hr at 1500 F the sample was removed and examined; there was no visible change in the coating. The sample was again placed in the furnace and heated 3 hr at 1650 F. The higher temperature produced minute surface blisters on the coating, which was otherwise still in-

TAKE YOUR PICK!

Special Chromalox features solve 3 spot heating problems

FLEXING



Spring strain reliever of high temperature stainless steel for applications in which cartridge heater leads flex. High tensile spring, mechanically locked to heater, covers lead wires a distance sufficient to distribute stress.

MOISTURE

Moisture-resistant flexible brass conduit protects lead wires of cartridge heaters operating in presence of steam, water, oil and vapors. Also offers added protection from flexing, vibration and mechanical damage.

ABRASION

Flexible brass conduit protects cartridge heater lead wires against abrasion from other moving parts and from accidental mechanical damage. Safety factor where lead wires are exposed to machine operator.

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C-2101

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For more information, circle No. 493

tact. At the end of this heating period the specimen was water quenched without losing any trace of the coating.

3. A 4-in. square sample was placed in front of a furnace heated to 1400 F. The temperature on the other side of the very thin coated aluminum sheet ranged from 800 to 850 F, indicating a temperature gradient of between 550 and 600 F.

To see how well the ceramic coating adheres to aluminum, Dr. Huppert and his staff subjected a number of coated specimens to a 90-deg bend test. Some specimens did not show any loss of coating after bending, whereas others had only superficial cracking without damage to the oxide interface layer.

Fabrication

According to Dr. Huppert, the new coatings may be applied to aluminum alloys before final heat treating, thus combining heat treating of the metal and firing of the coating in a single operation. It is claimed that this feature not only reduces fabrication time and cost, but also insures optimum strength of the metal and good adherence of the coating.

Another fabrication advantage claimed for the ceramic coatings is low firing temperature. "Where previous ceramic coatings were fired at 975 F," Dr. Huppert says, "our coatings may be fired at much lower temperatures . . ." He did not reveal the firing temperatures.

Ceramic coated aluminum alloys can be bent, drilled, punched and sheared without fracture or damage to the coatings.

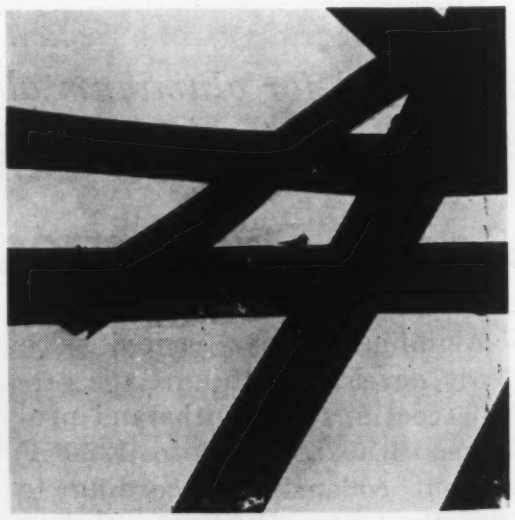
Strength and heat resistance offered by . . .

Improved Carbon Wool Fibers

■ Glossy black carbon wool, resembling steel or glass wool in appearance, is now commercially available from Robert Enterprises, 7224 Arrowood Rd, Washington 14, D. C. The material is recommended as a filtering medium and as a thermal insulation. The carbon fiber product is said to withstand temperatures over 5000 F under certain conditions.

Carbon fibers are not new, but their use has been limited because they usually break and disintegrate with the slightest vibrations. This new product apparently overcomes this drawback, for the producer says, "Carbon wool fibers are sufficiently strong to retain their fibrous form after being subjected to appreciable mechanical forces."

According to the producer, the



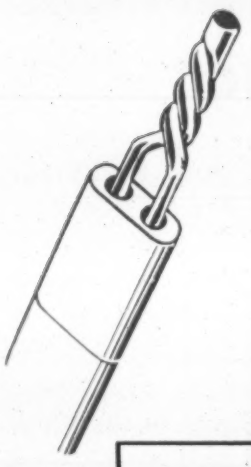
***Carbon fibers** as they appear under a microscope.*

PROPERTIES OF CARBON WOOL

Tensile Strength, psi	10
Density, lb/cu ft	½
Fiber Diameter, microns	5 to 50
Moisture Content, %	6.59
Carbon Content, %	92.79

Driver-Harris Announces Major Advance in Pyrometry!

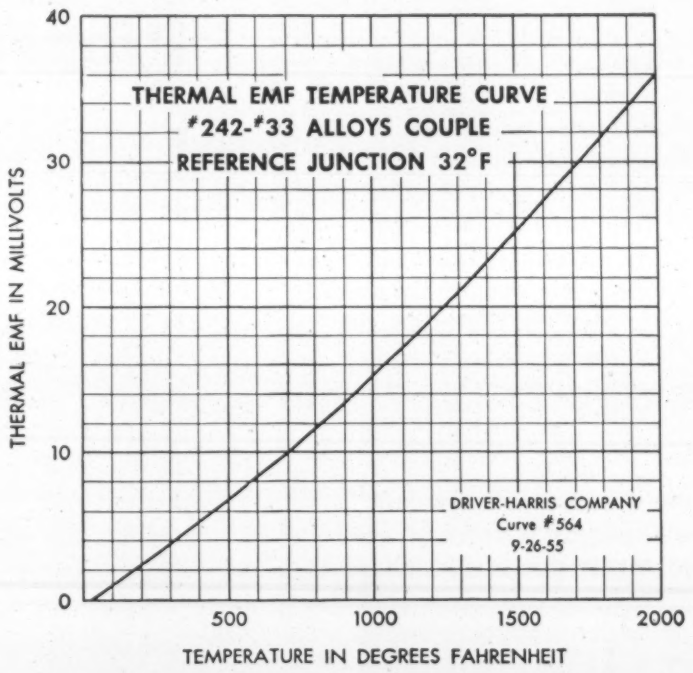
New #242-33 Thermocouple* for Reducing Atmospheres Maintains Calibration Through a Greatly Extended Life



This new Driver-Harris Thermocouple was developed primarily to withstand industrial reducing atmospheres at high temperatures and thereby to end the danger of runaway furnaces and ruined charges.

Unusually high resistance to "green-rot" attack is the outstanding property of the alloys of this thermocouple, whose analysis is:

Positive Leg (No. 242 Alloy)	Negative Leg (No. 33 Alloy)
80/20 Ni-Cr + Cb	3% Si-Ni



Although the thermal-emf response of this thermocouple is lower than the conventional thermocouple now in use, the slope of its temperature-emf curve is virtually parallel in the higher ranges of temperature in which both couples are designed to be used. Thus, the thermal-emf sensitivities are equivalent in the higher temperature ranges.

Tested against the conventional thermocouple in an atmosphere of the following nominal composition: CO...10%; CO_2...5%; CH_4...1%; H_2...16%; O_2...Nil; N_2...Balance (best for accelerating green-rot attack), exposure after 212 hours showed *only +0.13 mv. drift for the D-H thermocouple, and −7.54 mv. for the conventional thermocouple.*

When the thermal-emf of the conventional thermocouple *drops,* as in a reducing atmosphere such as this, the working temperature of the furnace controlled by it *rises.* However, when a #242-33 couple is used under the same conditions the thermal-emf remains substantially constant. This means that a furnace controlled with the new D-H thermocouple *cannot overheat and ruin charges.*

Members of the Heat-Treating and Instrument Manufacturing Industries are urged to investigate this new Driver-Harris Thermocouple without delay so that through their combined efforts all U. S. Industry can benefit. Complete technical data and application information is waiting for your inquiry. Write today to our Thermocouple Division.

*U. S. Patent No. 2,691,690

Driver-Harris COMPANY HARRISON, NEW JERSEY

BRANCHES: Chicago, Detroit, Cleveland, Louisville, Los Angeles, San Francisco In Canada: The B. GREENING WIRE COMPANY, Ltd., Hamilton, Ontario

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TUBING "know-how"

Do you know the great variety of parts that are being made from tubing—made better and at lower cost?

The advantages of tubular sections are many: you start with a material of close tolerances; it is available in practically any ductile metal; has better grain structure, further improved by cold working; offers extremely low scrap loss; requires less machining and no surface finishing; it is an aid to precision miniaturization; provides required strength with minimum weight—to mention only a few.

Uniform's tubing "know-how", gained through 20 years of specialized experience in the manufacture and application of small seamless tubing, is at your disposal. Profit from our industry-wide perspective. Discuss your parts problems with us and let us show you where tubing—or tubular components produced in our extensive forming and machining plant—will improve your product, speed production and reduce costs.

Uniform Tubing is available on three to four weeks delivery or better, in O.D.'s from .625" down to .010". Wall thickness down to .001". Tolerances to .00025", if required. Almost any metal analysis—ferrous, non-ferrous and the precious metals. Any specified temper. Fine finish. Every order is "made to order"—to exact specifications.

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carbon fibers can be activated up to 60 minutes with no appreciable loss in physical properties. The fibers can also be coated with magnesium, zinc and zirconium oxide coatings for fireproofing.

The carbon fibers are supplied in bulk or in the form of mats, ropes and blankets. The bulk carbon wool sells for $10 per cu ft in small lots and $5 per cu ft in lots of 1000 cu ft or more.

Here is the first report on . . .

Properties of Polypropylene

■ High heat resistance, good strength and toughness, as well as good chemical resistance and dielectric properties, are earmarks of a new thermoplastic resin now in commercial production at Montecatini Co., Milan, Italy. The Italian company's commercial outlet in the U. S. is Chemore Corp., 21 West St., New York 6. By all indications, it should not be long before the material is available in this country.

Isotactic polypropylene is the first of the ordered polymers produced by new polymerization techniques developed by G. Natta of Milan Polytechnic Institute. The new plastic, trademarked Moplen, differs structurally from polyethylene in that the molecule is isotactic, providing predictable frequency and location of side chains on the molecule.

Properties

Probably the most interesting single property of isotactic polypropylene is its heat resistance. The plastic has a melting point ranging from 325 to 340 F and a Vicat softening point (1-kg load) of greater than 300 F (Vicat softening point under 5-kg load is 200 to 210 F). It retains dimensional shape in the unstressed condition at temperatures up to 300 F.

The accompanying table presents typical physical, mechanical and electrical properties of the material. The low specific gravity of the material (0.90 to 0.91) could provide obvious economies in materials usage, since a given weight of material will provide more volume of material than plastics of higher specific gravity.

The material has somewhat higher tensile strength and rigidity than the high density polyethylenes. It has remarkably high compressive strength, and com-

Full Story Next Month

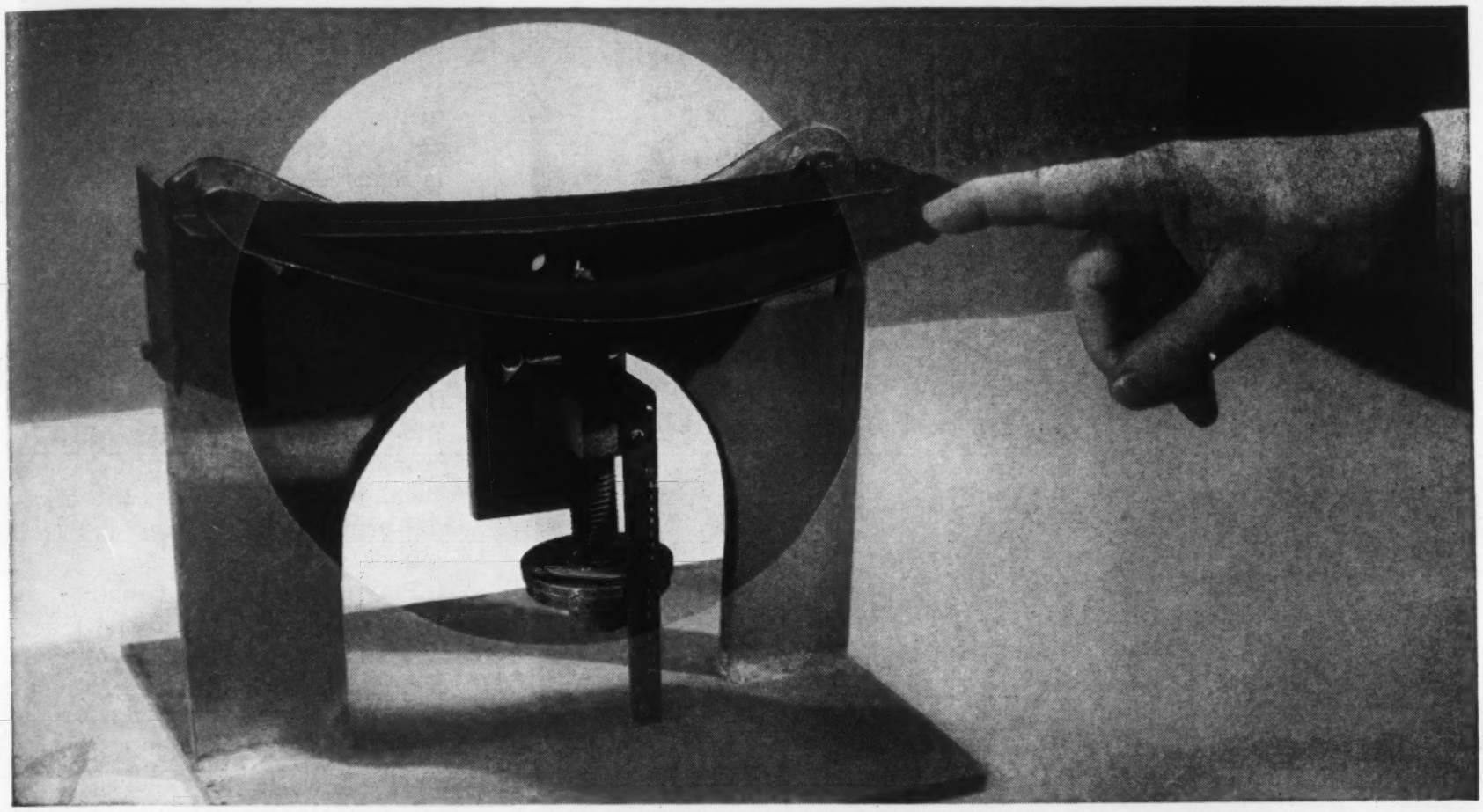
Next month in an exclusive article C. Crespi, of Montecatini, will discuss all of the engineering properties of isotactic polypropylene, the effects of various environments, design limitations as imposed by fabricating techniques, and applications.

TYPICAL PROPERTIES OF ISOTACTIC POLYPROPYLENE[a]

Specific Gravity	0.90-0.91
Melt Index, gm/10 min	6-20
Tensile Strength, 1000 psi	4.3-5.7
Elongation (total), %	500-700
Yield Strength, 1000 psi	4.3-4.9
Elongation (at yield), %	10-20
Stiffness (flexural), 1000 psi	114-142
Impact Str (Izod, unnotched), cm-kg/sq cm	>80
Young's Modulus, psi	$4.4\text{-}4.8 \times 10^5$
Rockwell Hardness	R85-95
Melting Point, F	325-340
Softening Point (Vicat), F	
5-Kg Load	201-208
1-Kg Load	>300
Brittle Temp, F	<14
Coef of Ther Cond, Btu/hr/sq ft/°F/in.	0.96
Coef of Ther Exp, per °F	61×10^{-6}
Dielectric Constant (10^6 cps)	2.0-2.1
Dissip Factor (10^6 cps)	0.0002-0.0003
Dielectric Strength, kv/mm	30-32
Volume Resistivity, ohm-cm	10^{16}

[a]Moplen.

How Armco Enameling Iron Helps Parts Hold Tolerances ...assures tight porcelain enamel-to-metal bond



Fired at the same temperature: Armco Enameling Iron (back) resists sag; Plain steel (front) sags badly.

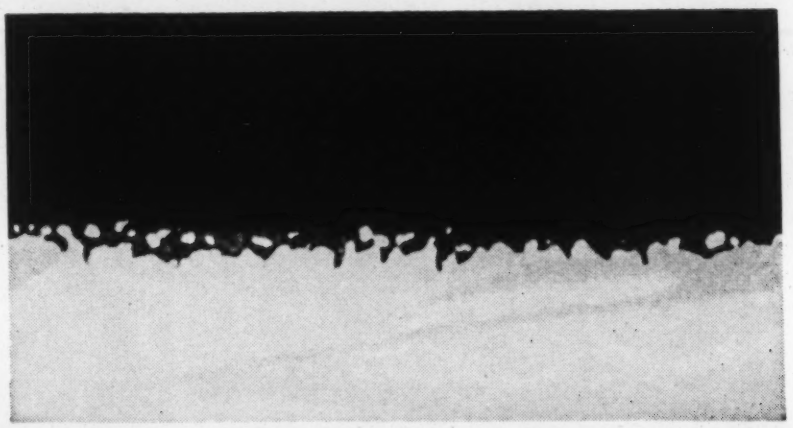
Armco Enameling Iron stubbornly withstands sag and distortion at all porcelain enamel firing temperatures. Dimensions stay accurate. Porcelain enameled parts fit. Rejects are practically eliminated.

But that's not the whole story about this special enameling iron. Product parts also have a tighter, more durable, enamel-to-metal bond. Microscopic projections on the surface of Armco Enameling Iron are the reason. These little metal "fingers" that are formed during firing take and hold the porcelain enamel finish in a tenacious grip. And, because this special enameling base contains a minimum of gas-forming impurities, perfect finish is easier to achieve.

Designed for One Job

Unlike many metals used for this purpose, Armco Enameling Iron is made *only* for porcelain enameling. That's why so many producers of high quality porcelain enameled products have specified this specially-processed enameling metal for more than 40 years.

For complete information, just fill in and mail the coupon for a copy of the catalog, "Armco Enameling Iron."



Tiny projections formed during firing on the surface of Armco Enameling Iron (above) are only about .000125-inch high. Although of microscopic size, they hold the finish in a tight grasp.

ARMCO STEEL CORPORATION
1817 Curtis Street, Middletown, Ohio

Please send me a copy of the catalog, "Armco Enameling Iron."

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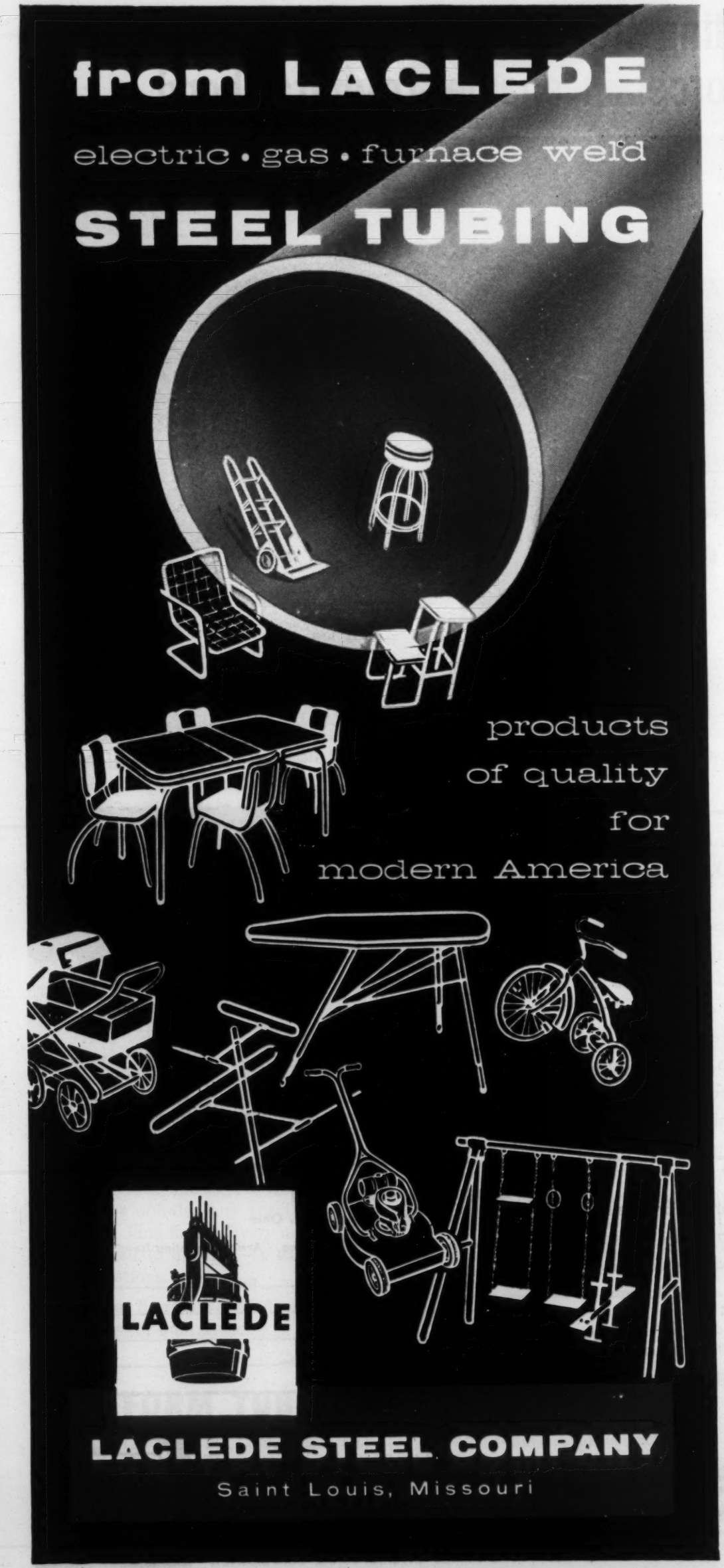
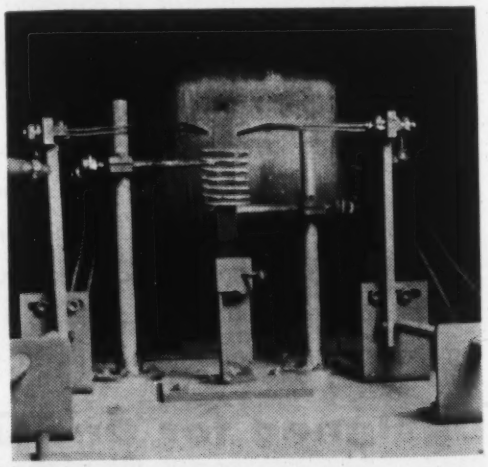


What's new IN MATERIALS

pressive yield strength values range from 8500 to 9900 psi. It is relatively hard, with a Rockwell hardness of R85 to R95, and impact strength is greater than 80 kg-cm per sq cm.

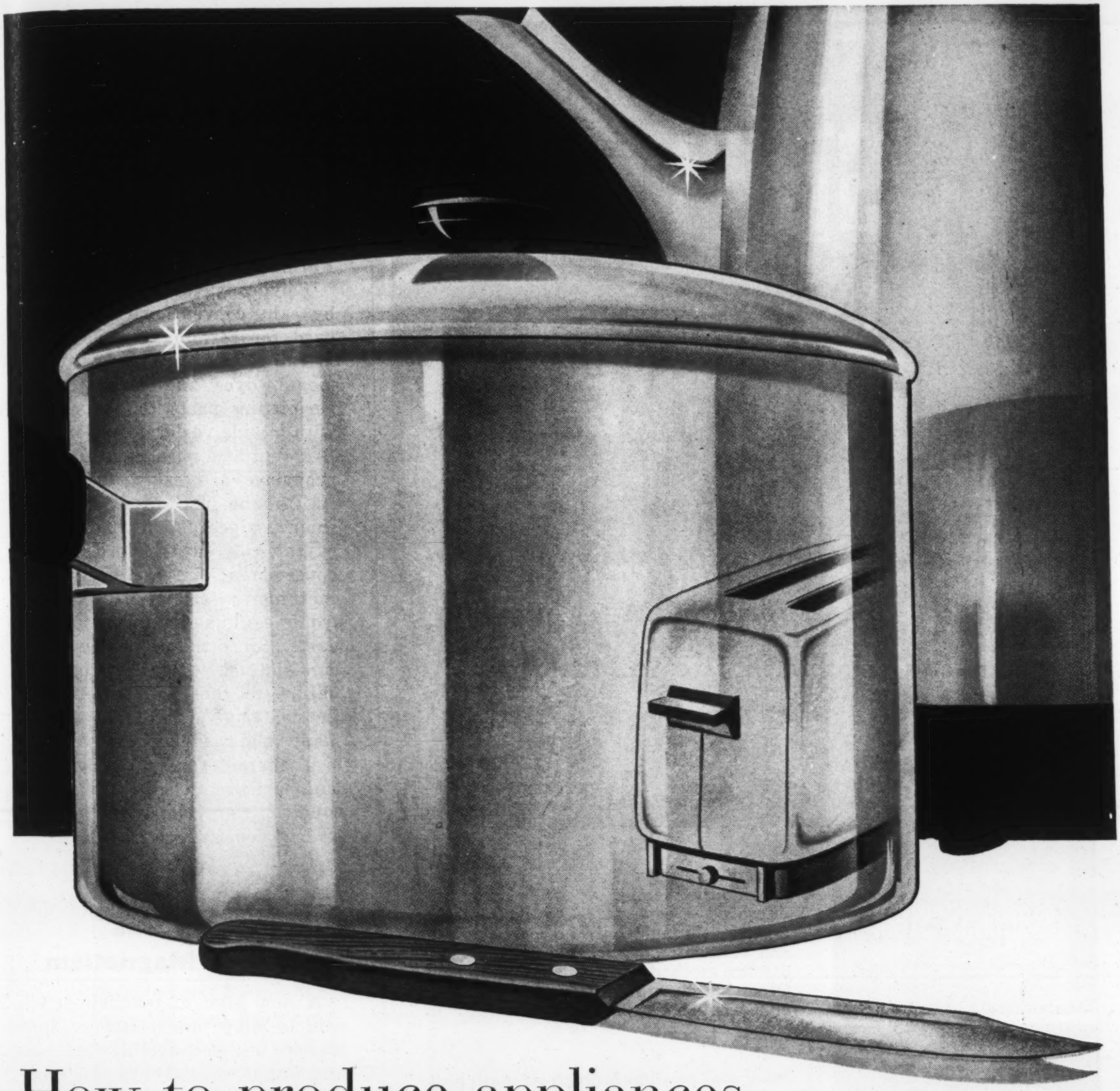
Electrical properties of isotactic polypropylene are similar to those of high density polyethylene. However, the superior mechanical and thermal properties of polypropylene, coupled with these electrical properties, make the material promising for many electrical applications.

Polypropylene is resistant to many chemical reagents, both acid and alkaline, and saline solutions even at elevated temperatures. At room temperature it is insoluble in and does not embrittle in contact with all organic solvents and polar substances. At temperatures higher than 176 F it is soluble in aromatic substances like toluene



Flammability of plastics—Shown above is a flammability test unit designed especially to evaluate flammability characteristics of electrical grade plastics laminates. Developed by the NEMA Switchgear Committee, the unit consists of a heating coil and specially designed electrodes. The electrodes emit a constant stream of high voltage sparks which ignite the gases arising from the heated plastics sample. The unit is said to accurately measure ignition and burning time of such plastics laminates as glass-reinforced polyester and epoxy resins.

For more information, turn to Reader Service card, circle No. 417



How to produce appliances with a built-in polish

Stainless is the one metal that maintains its beauty from plant to purchaser. Consumers appreciate its lifetime sparkle . . . carefree durability . . . ease of cleaning . . . substantial feel. And you'll like the clean, dependable way that you can work and form Crucible stainless.

Why *Crucible* stainless? Among the many good reasons are: ***Uniformity*** — strip and sheet unsurpassed in flatness and close tolerance control. ***Finish*** — fine finishes, in a wider choice. ***Fast Supply*** — wider assortment of grades, sizes, shapes — all available promptly through nearby Crucible warehouses.

Join the switch to Crucible stainless. You and your customers will be glad you did. Crucible Steel Company of America, The Oliver Building, Mellon Square, Pittsburgh 22, Pa.

Write for a free copy of the "Crucible Stainless Fabricator's Handbook".

CRUCIBLE first name in special purpose steels

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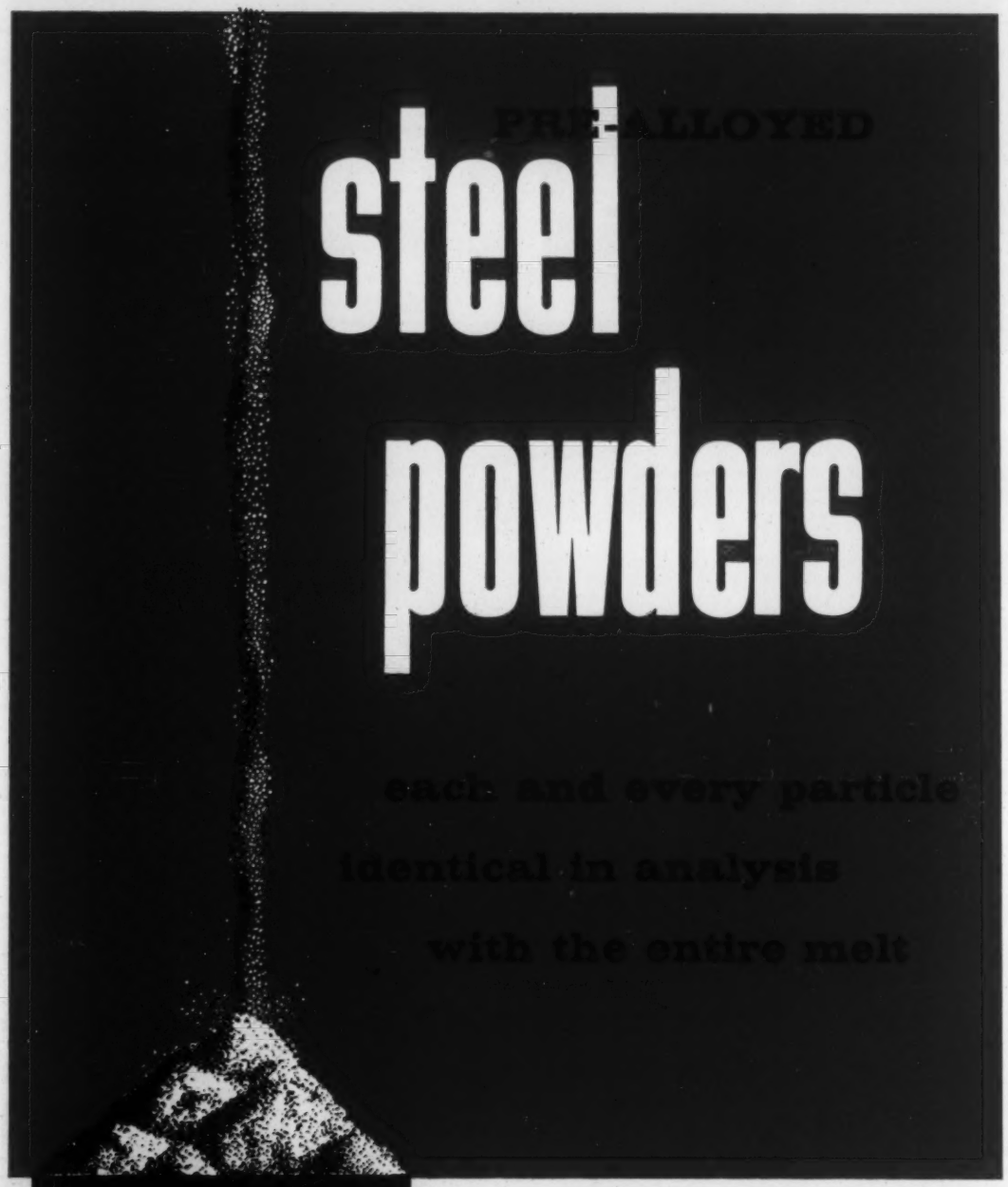

stainless steel

Vanadium-Alloys' Stainless Steel powders provide the metal powder fabricator with improved green strength and sintering qualities through control of particle shape and surface oxide. AISI grades 304 and 316 are stocked for immediate shipment. Other stainless grades and experimental alloys can be shipped promptly.

alloy steels

Alloy steel powders for high-strength parts are a Vanadium-Alloys specialty. Shipment of 4650A and 4630A is made from stock. Prompt shipments are offered for many other compositions, as specified.

special alloys

Special alloy powders of all types are produced, including brazing alloys, high-temperature alloys, super corrosion resistant grades, and electrical and magnetic alloys. Send us your requirements.

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and xylene and in chlorinated hydrocarbons.

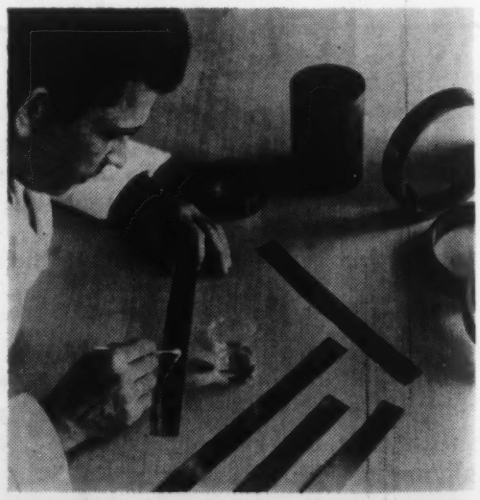
Formability and uses

Polypropylene can be fabricated by all conventional techniques used for forming thermoplastics. It can be easily mixed with pigments, dyes and carbon blacks, permitting parts to be produced with a wide variety of colors.

Potential applications for polypropylene are many and varied. It can be used for structural shapes, pipes and fittings; transparent, colored or colorless films; housewares; refrigerator parts; containers; electrical and electronic equipment; and automobile parts. Since the properties of the material are somewhat similar in nature to those of polyethylene, the material should find a great many applications where the general characteristics of polyethylene are required, but service conditions are too severe for high or low density polyethylenes.

Silicon Iron Has Four Way Magnetism

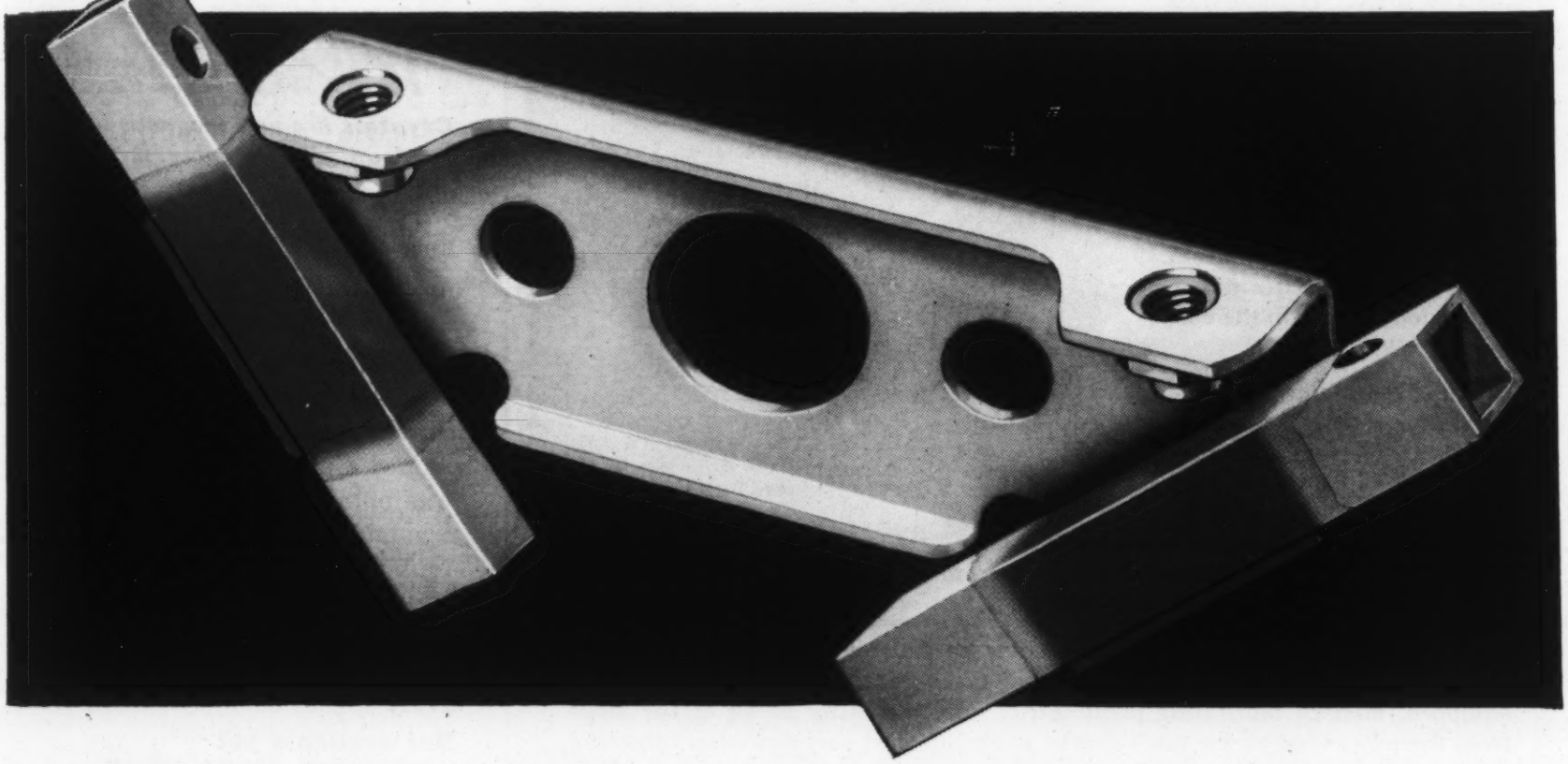
A new kind of magnetic steel, said to allow magnetism to "turn corners" in electrical devices, was announced recently by Westinghouse Electric Corp., Pittsburgh,



***Thin sheets** of Cubex magnetic steel, measuring 12 to 14 mils in thickness, have been produced on a pilot plant scale at Westinghouse.*

Jack & Heintz Saves $15.84 Per Hour...

with TOCCO* *Induction Brazing*



Brazing Costs Down—When Jack & Heintz engineers switched from torch brazing to automatic induction, brazing cost of these inverter brush mounts fell from $.05 to $.006 each—a reduction of 83% in direct labor costs alone! Additional savings result because less cleaning is required after TOCCO, and fuel costs are much lower, too.

Brazing Production Up—While costs dropped, production on the part zoomed—from 40 to 360 brazed assemblies per hour. Furthermore, rejects and scrap, formerly high, are now negligible.

Versatility—The part shown is just one of over 25 parts, large and small, which alert J & H engineers have converted from old-fashioned brazing methods to modern, automatic TOCCO. Overall brazing costs (TOCCO brazing versus former methods used) are down 75%—brazing speed, up 100%.

If the manufacture of your product involves brazing, heat-treating, forging or melting of ferrous or non-ferrous metals, don't overlook TOCCO as a sound method of increasing production, improving product quality and slashing costs.

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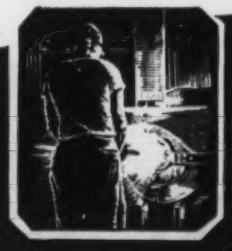


Fansteel Metallurgy

$86,000 per year SAVED BY SWITCHING TO FANSTEEL MOLYBDENUM FORGING

One company has made savings up to $86,000 per year, just because Fansteel's responsibility to a customer does not end with delivery of the order. It happened this way:

Cathode cone parts produced from Fansteel Molybdenum by hot forging and finish machining in the Fansteel Fabricating Plant.

An electronic tube manufacturer specified Fansteel high purity molybdenum for the cathode cones used in certain types of tubes. The cones were at first produced by completely machining them from Fansteel large diameter molybdenum rods in the customer's plant.

While this machining method was proving satisfactory, Fansteel engineers felt that forging these parts would result in substantial savings. With the cooperation of the customer, Fansteel engineers developed a technique for hot forging the base of the cone from a short molybdenum rod. The part is finished by machining and drilling.

This manufacturer immediately turned over to Fansteel the entire job of producing this part. The piece is forged and machined in Fansteel's completely equipped, modern fabricating plant. Strict quality control in all of the steps from the processing of the raw material to the finished part guarantees meeting the customer's rigid specifications.

SAVINGS

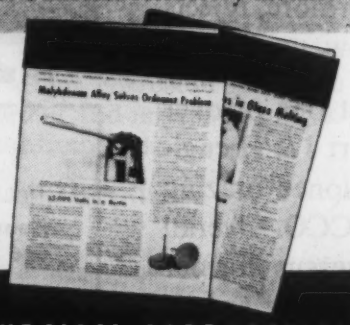
Previous method of machining complete part . . . . . $15.00 per part
Forging and finish machining in Fansteel plant . . 10.20 per part
SAVING PER PART . . $ 4.80
Average monthly production of 1500 parts

resulted in $7,200 saving per month or $86,400 per year.

Additional benefits resulted because the customer was relieved of concern for rejects and meeting schedules and was able to release machines and personnel for other work.

This is another typical example of how the combined experience and teamwork of Fansteel research scientists, metallurgists, designers and field engineers can result in substantial savings for users of molybdenum and other Fansteel refractory metals.

The true story reported here is typical of the news and technical comment contained in our publication, FANSTEEL METALLURGY. We'll be glad to place you on our mailing list; all we need is your name and address. No cost or obligation, naturally.



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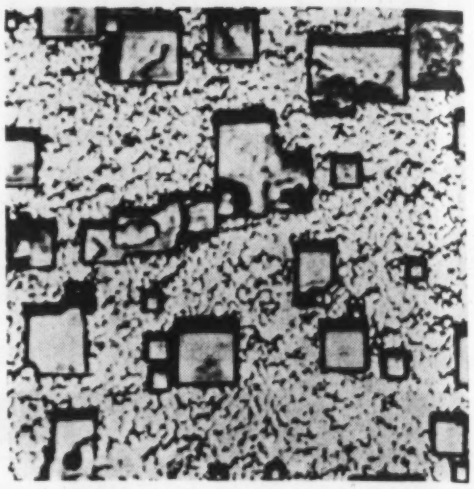

***Crystals** in a new magnetic steel are lined up like ice cubes in a refrigerator tray.*

Pa. The magnetic steel, known as "doubly - oriented" or "cube - oriented" silicon iron, can be easily magnetized in four directions instead of only two directions as in conventional magnetic steels. Trade named Cubex, the magnetic steel was obtained by reorganizing the crystal arrangement normally found in silicon iron. (For information on another doubly-oriented silicon iron, see MATERIALS IN DESIGN ENGINEERING, Nov '57, p 179.)

Not available yet

The material, currently being evaluated in the laboratory, is not commercially available at present. Westinghouse research scientists say they hope to make doubly-oriented silicon iron competitive in price with singly-oriented silicon iron once it gets into production.

In describing the new material, Dr. Clarence Zener, director of Westinghouse research, says, "The crystal arrangement in a sheet of Cubex might be compared to the arrangement of a tray of ice cubes. Each cube rests flat on one side and squarely faces the ends and sides of the tray. Therefore, the edges of each cube are exactly aligned with each other and are always parallel to the ends (width) and sides (length) of the tray. This is the way crystals in Cubex steel are aligned. Since the cube

METALLURGISTS • PHYSICAL CHEMISTS • CERAMISTS • SOLID STATE PHYSICISTS

FOR Development of Materials to Withstand Radiation Effects and Thermal Stresses

At the Aircraft Nuclear Propulsion Department of General Electric, development of the direct cycle nuclear propulsion system for aircraft has created problems of a type never faced before: metallurgists and ceramists at ANP must develop structures and components *to resist attrition due to radiative and intense thermal conditions.*

Engineers and specialists: B.S., M.S., Ph.D. — with 5-10 years' experience in metallurgy or ceramics can put their talents to *immediate use* at ANP, striking out along new approaches in:

PROBLEM ON HIGH TEMPERATURE, NON-POISONING BRAZING RECENTLY SOLVED BY ANP MEN:

Engineers and specialists at ANP — constantly faced with developing new principles and techniques in orthodox disciplines — recently had to create a boron-free brazing alloy for use in reactor core components. Their solution:

DEVELOPMENT OF A NEW BRAZE ALLOY

Melting Point	at 2033°F.
Brazing Temperature	2100-2150°
Tensile Strength	(at 1200°) 60,000 psi

Metal Processing:
casting, rolling, forging, extruding, swaging, plating, metallizing, brazing
Vacuum Metallurgy:
arc & induction melting, zone refining, brazing, sintering
Welding Refractory Metals
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OPENINGS AT ALL LEVELS

Opportunities are available for those who prefer either analytical operations or direct experimental investigations.

NUCLEAR EXPERIENCE NOT ESSENTIAL

Graduate study, seminars and contact with expert associates help you to develop nuclear competence in your specialty. (A few positions in Components In-Pile Test Scheduling *do* require men with nuclear experience.)

Publication of technical papers is encouraged.

LOCATION

Near attractive suburban communities only minutes away from Cincinnati, Ohio. A progressive city with many cultural facilities, Cincinnati is known as both an engineering center and a fine place to live. (A few positions are open in Idaho Falls, Idaho.)

Please address your resume in full confidence to:

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ALL TYPES OF FURNACE TREATED STEELS

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What's new IN MATERIALS

edges represent easy directions of magnetization, good magnetic paths exist along both the width and length of the sheet."

Potential uses

How soon doubly-oriented silicon iron will find use in the electrical industry Westinghouse will not predict. The company says specialized uses requiring only thin sheets will no doubt be the first commercial applications to be encountered, possibly within the next few months. Greatest use will probably be in magnetic cores used in such electrical devices as transformers and motors.

Development of the new magnetic steel originated at Siemens-Halske in Germany and was continued at Westinghouse research laboratories in this country.

Polyethylene Resin Made in Four Types

Marlex 50 high density polyethylene resin, introduced about three years ago by Phillips Chemical Co., Bartlesville, Okla., is now offered in four different types for easier processing. The resins, called Types 9, 15, 35 and 50, are designed primarily for injection molding and extrusion of plastics goods. The key to classification of the resins is melt index which varies from resin to resin. The resins and their properties are as follows:

Type 9 is essentially the same as the single Marlex 50 resin previously offered by the company. It has a melt index of 0.9, an impact strength of 4.0 ft-lb per in., an environmental stress cracking value (Bell Laboratories test) of 14 hr, a brittleness temperature of—180 F and an elongation of 25%.

Type 15 processes more easily than Type 9 but has less impact and environmental stress cracking resistance. It has a melt index of 1.5, an impact strength of 2.5

TUBING IDEAS LIKE THESE

simplify design, increase production, reduce cost!

Ideas for new or improved products are easy and economical to carry out when they call for Van Huffel tubing.

Shown are a few of the ideas Van Huffel has roller die, cold formed to any length from a wide variety of metals: hot or cold rolled steel, stainless steel, high strength steels, aluminum, copper, brass, etc., in gauges from .003 to .312; from forming dies designed and built in our own plant.

In addition, Van Huffel fabricating services: notching, bending, punching, tapering, flanging, beading, etc., can help you make your ideas take shape . . . profitably.

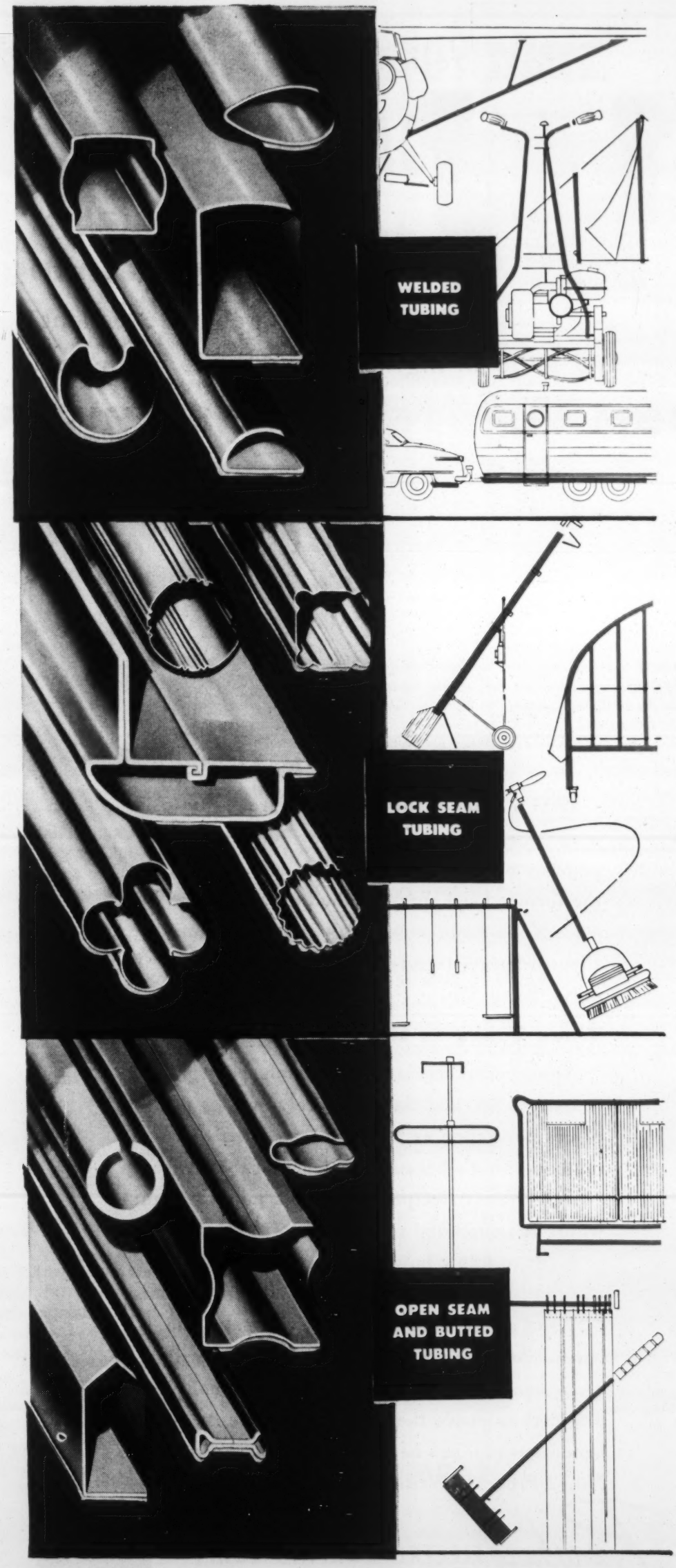
FOR YOUR FILES

24-page Size Brochure on Van Huffel lock seam, butted, welded tubing; angles and channels.

32-page Welded Tubing Handbook containing engineering data in handy reference form.

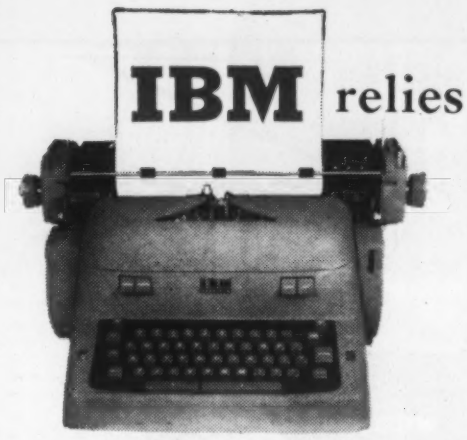
van huffel

TUBE CORPORATION • WARREN, OHIO



where ideas take shape

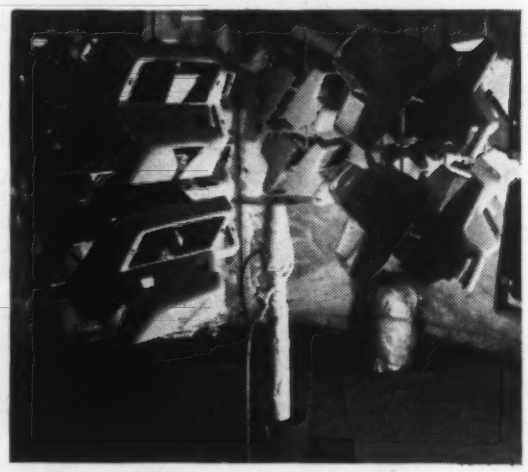
For more information, turn to Reader Service card, circle No. 529



IBM relies on **RANSBURG NO. 2 PROCESS Electrostatic Spray Painting**

to get the excellent and uniform high quality wrinkle finish on all

IBM ELECTRIC TYPEWRITERS



Both prime and finish coats are uniformly applied to IBM Electric Typewriter cases as they rotate around the floor-mounted Ransburg No. 2 Process reciprocating disks. Automatic Electro-Spray provides three times as many pieces per gallon as by former hand spray.

IBM's strict quality standards are easily maintained with Ransburg No. 2 Process in the painting of Electric Typewriter parts. Rejects by the former hand spray method used to run as high as 30% on some parts. Now, with automatic Electro-Spray, rejects for all reasons are only 3% to 5%.

Three Times as Many Pieces per Gallon!

Along with increased production, paint mileage is stepped up, and they get three times as many pieces per gallon as by the former hand spray method. That's because efficiency of the Ransburg No. 2 Process Reciprocating Disk puts the paint where it's supposed to go . . . on the parts.

Want to know how Ransburg Electro-Spray can improve the quality of your painted products . . . and at the same time, cut your paint and labor costs? At no obligation to you, we will make complete laboratory tests with your products to prove the advantages and cost saving benefits which can be yours with Ransburg No. 2 Process. Write or call.

Ransburg **ELECTRO-COATING CORP.**
Indianapolis 7, Indiana

RANSBURG

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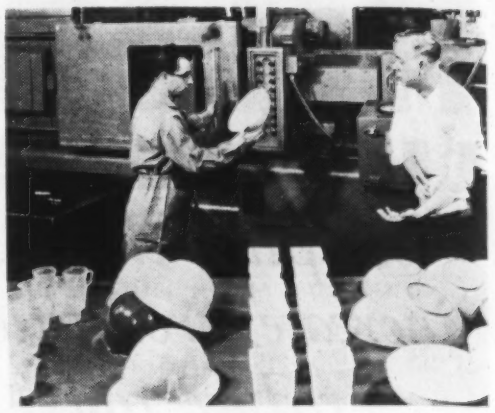
What's new IN MATERIALS



***Typical products** made of Marlex polyethylene resins are (left to right) beakers made of Type 9, safety helmets made of Type 15, refrigerator dishes made of Type 35 and salad bowls made of Type 50.*

ft-lb per in., an environmental stress cracking value of 10 hr, a brittleness temperature of below —180 F and an elongation of 20%.

Type 35 has moderate impact resistance and is recommended for such plastics products as thin-wall disposable containers and large moldings. It has a melt index of 3.5, an impact strength of 1.5 ft-lb per in., an environmental stress cracking value of 2 hr, a brittleness temperature of below —150 F and an elongation of 15%.

Type 50 is a high flow material that is recommended for applications that require the maximum in processibility. The resin has a melt index of 5, an impact strength of 1.2 ft-lb per in., an environmental stress cracking value of 1 hr, a brittleness temperature of —100 F and an elongation of 12%.

All four types of the high density polyethylene have the properties shown in the accompanying table.

PROPERTIES OF MARLEX 50

Tensile Strength, psi	4400
Stiffness, psi	150,000
Durometer Hardness	D 68
Softening Temperature, F	260
Density	0.96

(more What's New on p 176)

No. 5
of a series of ads dealing with basic facts about thermostatic metals.

Designing for Product Improvement With WILCO THERMOMETAL®

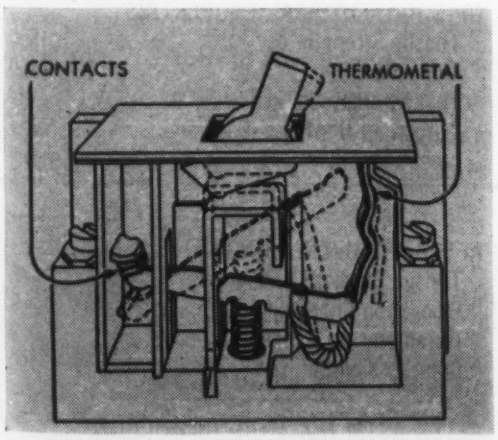
Thermometal in Sequence Control

Because Thermometal (Thermostatic Metals) changes shape with change in temperature it is used not only for temperature indication, temperature control and temperature compensation, but also in applications which require sequence control.

In these the Thermometal is heated by the load current (or a proportional part of it) or by an auxiliary heater, and the resultant temperature change of the Thermometal is transformed into motion in order to initiate some other function. Typical examples of the use of Thermometal for sequence control are found in electrical circuit breakers, overload relays, time delay relays, oil burner controls, automotive dashboard instruments, thermal demand meters, etc.

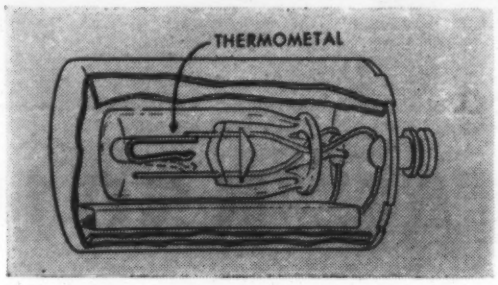
Thermometal is ideally suited for sequence control by functional heating because:

1. It is supplied in a wide range of electrical resistivities, each having approximately the same deflection (or activity) with change in temperature. Thus the manufacturer of a current-responsive device, such as a circuit breaker, can utilize a single design for a wide range of current capacities simply by selecting Thermometal of fixed dimensions but different electrical resistivity to obtain different current ratings for the breaker.



Cantilever element in Circuit Breaker.

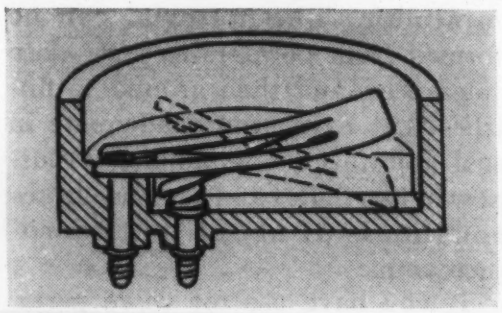
2. Thermometal produces motion proportional to actual temperature change without employing bearings, moving joints, or other linkages. This makes possible the relatively simple and



U-shape element in Lamp Starter.

economical design of many sequence-controlled devices such as thermal relays for timing or remote control.

3. In small pieces of thin gauge it will deflect considerably with a relatively small amount of heating, returning to starting position in response to small amount of cooling. A typical application of this kind is illustrated by the sequence of operations of a fluorescent lamp starter. The U-shape Thermometal is actually heated by the glow between it and the free terminal until the bimetal touches the free terminal



Snap-action element in Circuit Breaker.

which extinguishes the glow. Then, on cooling, the bimetal breaks a highly inductive circuit, providing the voltage required to start the lamp.

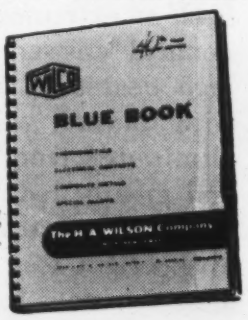
4. Thermometal is a unique thermal element, in that it can be rolled into any thickness and formed into almost any shape required. This fact enables the design engineer to apply it in the form of a cantilever blade or a snap blade, a U-shape, a helix, or a coil, in almost any mechanical size and configuration according to the physical needs of the device for sequence control. Thus, Thermometal is free from many of the limitations of other thermal elements used for sequence control.

Factors Governing Selection

1. Temperature change over which activity or sequence control is required.
2. Maximum and minimum temperature encountered in service.
3. The amount of movement and force required over a given temperature range.
4. Electrical and thermal conductivity for the required application.
5. Space limitations which govern the shape required.

The H. A. Wilson Company, American pioneer in the development and manufacture of thermostatic metals, produces over 40 varieties of Thermometal, as well as a complete line of electrical contacts. In many temperature control units both Thermometal and electrical contacts are used. We make a specialty of supplying complete sub-assemblies for these devices, including mounting brackets, pigtails, and other current-carrying members.

Reprints of this series are available on request. For further information about our products, ask for the Wilco Blue Book, the most complete reference manual ever written on Thermometal. And if you have any immediate application problem for Thermometal or other Wilco products, please tell us. Our engineering service is at your disposal.



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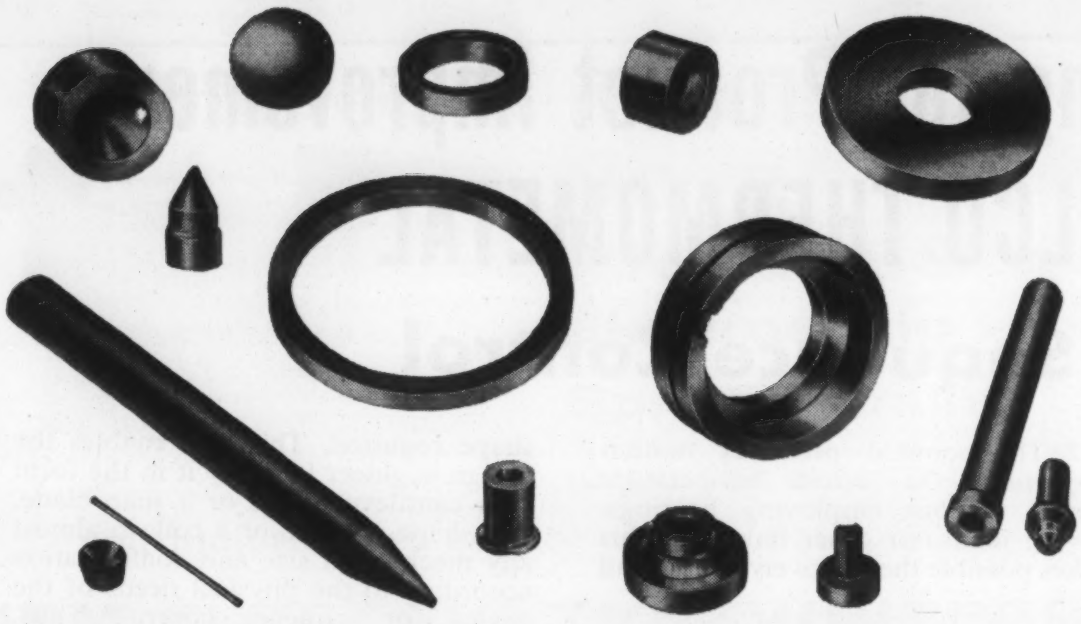

In parts like these
KENNAMETAL* K501
EQUALS the Noble Metals in Corrosion Resistance...
BETTERS them in Economy and Resistance to Wear!

In the chemical field, and also in the food, paint, petroleum, oil refining, paper and atomic energy industries, equipment components like the ones shown above are often exposed to extremely severe corrosion.

When—as often happens—the corrosive attack is complicated by excessive wear conditions, and when contamination of the batches handled must be avoided, the designer and plant engineer have a real problem in materials selections.

Kennametal K501 has proven itself an extremely effective and economical answer, as it combines a high degree of corrosion resistance with unusual wear resistance, that eliminates frequent replacement, and greatly reduces contamination.

Laboratory tests show no measurable weight loss of a K501 sample after five days in boiling 5% HNO_3 and 5% H_2SO_4. Loss was only 74/mg/dm/day in boiling 5% HCl.

Hardness, RA is 91.0 minimum; transverse rupture strength is 125,000 psi minimum; and, density is 15.10 minimum. The material can be formed from powders to very close tolerances, and then ground to finishes that have proved adequate in seal applications demanding a flatness of two light bands, and a surface roughness of about one microinch rmp.

If you have use for valve parts, balls and seats, guides, wear rails, slitting and cutting parts, non-lubricated guides and bushings, metering orifices, sealing rings, in applications where corrosion and wear are problems, ask for full information about Kennametal's K501. Just write to: KENNAMETAL INC., Dept. MDE, Latrobe, Pennsylvania.

*Trademark of a series of hard carbide alloys of tungsten, tungsten-titanium and tantalum.

C-3067

INDUSTRY AND KENNAMETAL ...Partners in Progress

For more information, turn to Reader Service card, circle No. 400

What's new IN MATERIALS

Silicone Rubber Tape Holds Well at 450 F

A new pressure sensitive silicone rubber tape does not soften or lose its tack at high temperatures. Laboratory tests show the tape has a pressure sensitive, fusible surface after air oven aging for 70 hr at 450 F.

The cured, unsupported tape, made by Norris Mfg. Co., 7 Schoon Ave., Hawthorne, N. J. and called Norsil, is available in 10, 20 and 30-mil thicknesses. It sells for $2.25 a single roll in 10-mil thicknesses, $3.50 a roll in 20-mil thicknesses and $5.25 a roll in 30-mil thicknesses.

The silicone rubber used in the tape is a "fusible" silicone rubber compound developed by Silicones Div., Union Carbide Corp. Designated K-1605 R, it is said to bond to itself, to other silicone rubbers and to most metals. Union Carbide says, "Application of pressure at a temperature of 350 F for 30 min is sufficient for bonding K-1605 R to itself and to other silicone rubbers." Metal bonding is achieved by priming

PROPERTIES OF K-1605 R

ORIGINAL PHYSICAL PROPERTIES	
Tensile Strength, psi	800
Elongation, %	400
Tear Strength, lb/in.	94
Durometer Hardness	A 47
Linear Shrinkage, %	6.6
Specific Gravity	1.15
AFTER AIR OVEN AGING[a]	
Tensile Strength Change, %	−6
Elongation Change, %	−9
Durometer A Change, %	+3
Compression Set, %[b]	50
AFTER ASTM NO. 1 OIL IMMERSION[b]	
Tensile Strength Change, %	−36
Elongation Change, %	+8
Durometer A Change, %	−9
ELECTRICAL PROPERTIES	
Dielectric Constant (100 cps)	2.95
Dielectric Strength, v/mil	745
Power Factor (100 cps)	0.0013
Volume Resistivity, ohm-cm	3.9

[a]Aged 70 hr at 450 F.
[b]Aged 70 hr at 300 F.

EFFECT OF INTEGRAL FINNED TUBE ON HEAT TRANSFER PERFORMANCES

In addition to pioneering in the development of integrally-finned condenser tube, Wolverine Tube has also been responsible for coining the various designations used to describe different types of integrally finned tubing. Because of the increasing popularity of Wolverine Trufin®, we are often asked to explain just what these designations mean.

Actually, Wolverine Trufin is available in six different types—each designed for use in specific heat transfer applications. The most widely used is Trufin Type S/T named by Wolverine to identify its use in shell and tube condensers. Trufin Type S/T is a low finned tube with either 16 or 19 fins per inch (depending on alloy). The ratio of outside-to-inside surface area is approximately 3.75 to 1.

Wolverine also produces Trufin Type W/H, so named because it was designed primarily for use in water heaters. Trufin Type W/H is a high finned tube with 11 fins per inch. It has an outside-to-inside surface ratio of approximately 4.75 to 1.

To help the processing industry do a better hydrocarbon cooling job Wolverine developed an all-aluminum Trufin tube with integral fins on the outside and longitudinal fins on the inside. This tube is called Trufin Type I/L (internal longitudinal). It is available with 5, 7, 9, or 11 fins on the outside and has sufficient fins on the inside to approximately double the surface area. In addition to hydrocarbon cooling, Trufin Type I/L is also ideal for air cooling oil or in air-type refrigeration evaporators.

Trufin Type L/C is a high finned-lightweight aluminum tube mechanically bonded to an interior liner of any metal. Type L/C was designed to economically provide an extended surface tube with a liner core permitting adaptation to a variety of corrosion and/or pressure requirements. Type L/C, too, is ideal for air-cooled operations.

To facilitate insert type end connections by brazing, Wolverine developed an extended surface tubing with a controlled inside diameter—named it Trufin Type H/A (high area). Trufin Type H/A is a high finned tube with an outside-to-inside surface ratio of approximately 8:1. Air or gas flows outside the tube to be heated or cooled. The heating or cooling liquid is passed through the inside of the tube.

Finally there's Trufin Type H/R (high root)—similar to Type H/A. The root diameter is closely controlled and sufficient wall thickness allowed to permit the removal of fins for rolling into tube sheets. Type H/R is a high finned tube —has an outside-to-inside surface ratio of approximately 8:1.

And there, briefly, is a look into the background of integrally finned condenser tubing—a Wolverine development that is becoming more and more important with the passing of each day.

LOOK

TRUFIN TYPE S/T

TRUFIN TYPE H/A

TRUFIN TYPE L/C

TRUFIN TYPE H/R

TRUFIN TYPE W/H

TRUFIN TYPE I/L

SIX TYPES

FINS actually

E-X-T-R-U-D-E-D

from the tube wall!

The fact that its fins are part of the tube wall is the secret of the construction of Wolverine Trufin. It's the secret too, of the amazing performance records which Trufin-tubed heat exchange units are hanging up every day.

Because the fins and tube are all one piece, you are assured of constant efficiency. Fins are not impaired by vibration, temperature change or varying pressure. Trufin transfers *more* BTU's per foot of tube—permits you to design more compact units—steps up the capacity of existing ones.

Trufin is fabricated as easily as plain tube, too. In fact, standard tools and techniques are used. Fabricated Trufin units are often stronger than units using plain tube because fins provide additional support at bends. Remember: You can *depend* on Trufin for *dependable* heat transfer!

WRITE FOR CATALOG

BUY WOLVERINE TUBE—IT'S MADE IN AMERICA

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CANADA VULCANIZER AND EQUIPMENT COMPANY LIMITED

WOLVERINE TUBE

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Manufacturers of Quality-Controlled Tubing and Extruded Aluminum Shapes

Wolverine Trufin is available in Canada through the Unifin Tube Company, London, Ontario.

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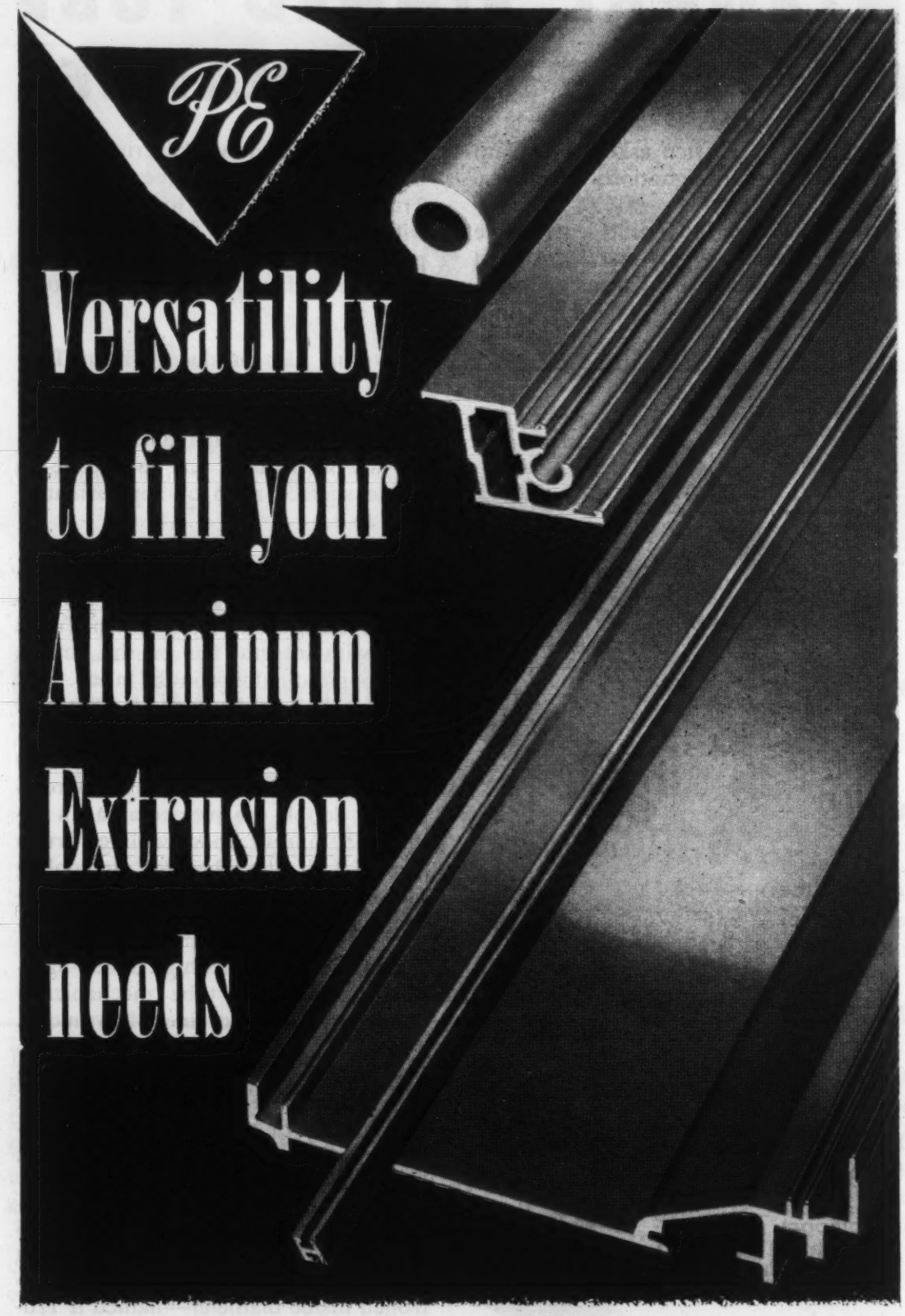
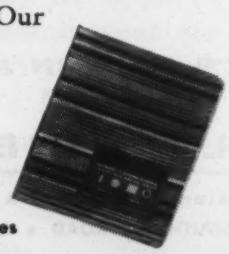
PE

Versatility to fill your Aluminum Extrusion needs



When you specify Precision Extrusions you will learn why an increasing number of design engineers and purchasing executives are turning here for all aluminum extrusion needs. You'll find experienced PE engineers are eager to help in developing extrusions that cut manufacturing costs, improve product quality and increase appeal. You'll find PE can provide finished extrusions with special characteristics according to your needs. Our extensive metallurgical and mill experience is augmented by versatile press equipment and modern, quality-control from billet casting to finished extrusion. Our specialization in producing aluminum extrusions only is your assurance of prompt, personalized, and confidential attention. Call a PE engineer to work with you on your current project.



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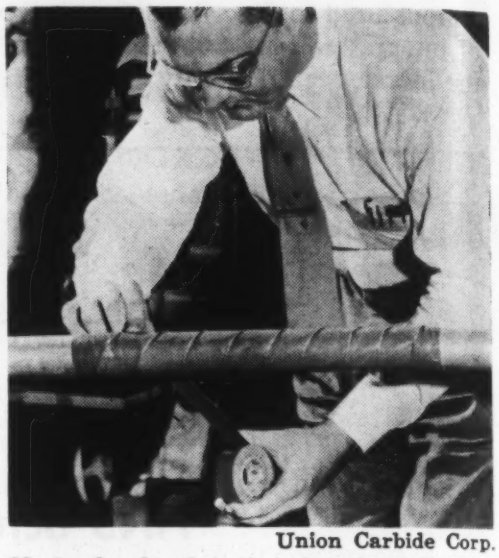

Union Carbide Corp.
***Hot air duct** is insulated with heat resistant silicone rubber tape.*

the metal, air drying it for 10 min, and applying pressure to the tape and metal for 30 min at 350 F.

Applications

In laboratory and field evaluation tests, the unsupported tape has proved useful in splicing connections on ovens and heaters. The tape has also proved useful as an insulation on various electrical and electronic parts.

According to Carbide, fusible, supported silicone rubber tapes have been made in the laboratory and should find use as an insulation in hot air ducts and as a wrapping for coils in motors and generators.

Man-Made Diamonds Will Be Sold Soon

Man-made industrial diamonds, first developed about two years ago (see MATERIALS & METHODS, Apr '55, p 12), will be commercially available within the next few months, according to officials of General Electric Co., Metallurgical Products Dept., Detroit 32 The man-made diamonds, said to be equal in hardness and strength to natural diamonds, are made by subjecting carbonaceous materials to pressures over 1,000,000 psi and to temperatures higher than

"Abrasion resistance is nylon's chief advantage in this application," declares Bob Kile (office manager of the Line Scale Company in Oklahoma City), as he discusses with Ray Stroud (General Manager of Continental Plastics) reasons why nylon makes a better oil pipeline valve. Read below how nylon outperformed both metal and other resins.

Oil field equipment manufacturer reports:

"Why we switched to pipeline valve plates molded by Continental from Spencer Nylon"

Unique combination of durability plus "give" offers ideal solution to equipment problem:

"Special problems arise in the manufacture of oil pipeline valves," explains Bob Kile, office manager of the Line Scale Company, Oklahoma City, manufacturers of oil field equipment. "We don't use metal disks; with metal working against metal 500 times a minute a brass fitting would soon be pitted.

"A thermo-setting plastic disappointed us, too. The material was laminated, and fluids would penetrate the crevices until they soaked off a layer of the valve. And because of its relatively low abrasion resistance it, too, often became pitted.

"But Spencer Nylon solved the problem. Using Spencer Nylon, Continental Plastics molded for us a piece which has operated so satisfactorily that we are now using nylon valves in the chemical field as well as for petroleum!

"Nylon outlasts other plastic materials many times over in this application," Kile declares. "Before, when a piece of grit got under the plate, pressure of the liquid began to erode the plate. Nylon, however, has a tendency to 'give' in such a case, rather than to pit, and then the particle washes away.

"In our own test, we circulated brass shavings in water through a pump, and found that the shavings imbedded themselves in the nylon but didn't hurt the efficiency of the valve. Washing later carried the shavings out. In addition, with a nylon disk, when one side gets worn, you can turn it over and use the other side."

At the same time, Spencer Nylon has many advantages to molders. It is more dependable and easier to mold than old-type nylon. That's because Spencer Nylon has a wider plasticizing range and a wider temperature working range.

You, too, may find that Spencer Nylon offers an ideal solution to a molding problem, or that a Spencer Nylon-molded part gives you the exact combination of features that some phase of your manufacturing process demands. For more information, write to Spencer Nylon, Spencer Chemical Company, 523 Dwight Building, Kansas City 5, Missouri.

NOW! NYLON *by* SPENCER

SPENCER

SPENCER CHEMICAL COMPANY

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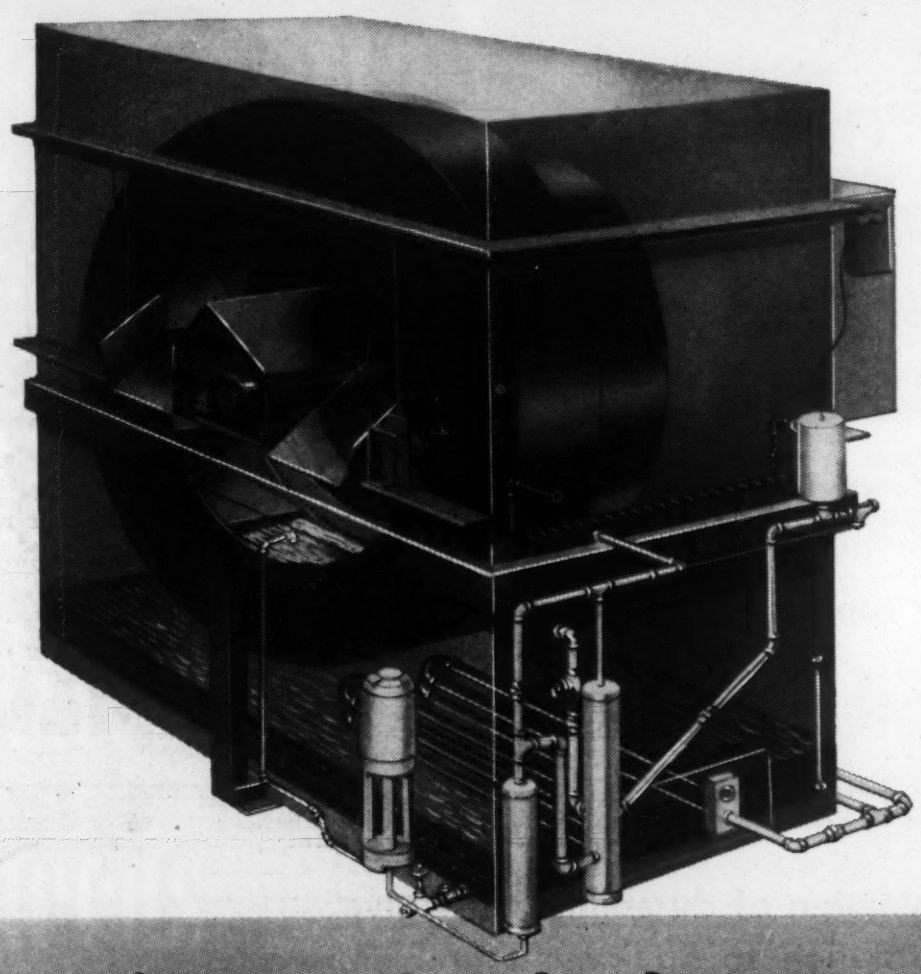
Revolutionary New Automated Degreaser by DETREX



Outstanding new type Rotary Drum Degreaser saves space, cuts costs, needs only small investment

Combining solvent degreasing with automated work handling, the new DETREX 1DD750 provides thorough cleaning of such products as nuts, bolts, fasteners, stampings and screw machine parts. In-process cleaning—cleaning before and after heat treatment—cleaning before plating, phosphatizing, bright dipping, etc. —final cleaning—all are handled with important savings in initial investment, operating costs and space requirements.

Steam heated and measuring only 6′ 6″ wide and 6′ 0″ high, and 4′ 0″ in direction of work flow, the 1DD750 handles five cubic feet per hour with a rated capacity of 2000 lbs. steel or brass per hour.

Only DETREX produces *both* equipment and chemicals to fill the widest range of metal cleaning and processing needs. DETREX can properly recommend, install and service the right combination of facilities for any cleaning application.

Acclaimed at NATIONAL METAL EXPOSITION
Hundreds of Inquiries, Dozens of Orders Received

DETREX CHEMICAL INDUSTRIES, INC.
BOX 501, DEPT. E-903, DETROIT 32, MICH.

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What's new IN MATERIALS

3000 F. Earlier this year, GE scientists produced another man-made substance, Borazon, under similar high pressures and temperatures (see MATERIALS & METHODS, May '57, p 194).

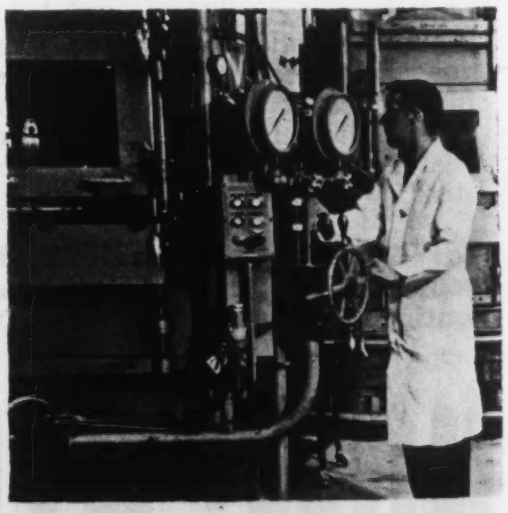
Not an imitation

Company officials emphasize that the man-made material is not an imitation diamond but rather a material that has all the variations of color, clarity and crystallinity found in a natural diamond.

The diamonds are solely for industrial uses and not for jewelry, according to the producer. Their use in industrial products will be mainly in grinding wheels and lapping compounds for sawing, grinding and polishing hard materials. The price of man-made diamonds will be slightly above the price of natural diamonds.

Background

Scientific attempts to make diamond date from 1797 when diamond was shown to be elemental carbon. Work at the Bureau of Standards did much to clarify the carbon phase diagram, and at Harvard University P. W. Bridgman made great strides in developing means for containing high pressures and in finding new techniques for measuring extremely high temperatures and pressures. Bridgman succeeded in reaching temperatures of 3500 to 5000 F



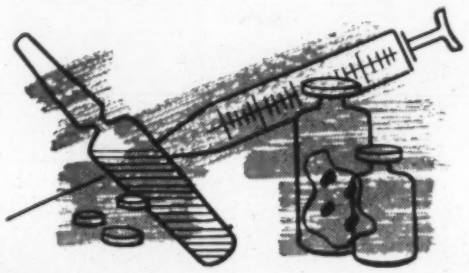
***Equipment** like this is used to make man-made industrial diamonds under extremely high pressures and temperatures.*

Which New CO_2 Application Will Help You Most?

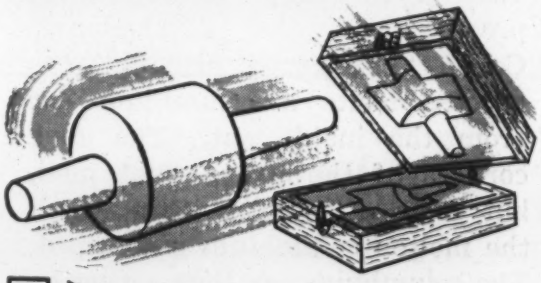
"CO_2 applications are unlimited"... a broad statement, but literally true. New ways in which this most versatile of all gases is improving products, cutting costs and saving time and labor are being developed almost daily. Some of the applications discussed here will be of direct, primary interest to you. Other uses, while perhaps not in your immediate specialty, may well be *adaptable* to your field. Check the box by each application on which you'd like detailed, technical data and mail to:

LIQUID CARBONIC
Division of General Dynamics Corporation
3172 South Kedzie Avenue • Chicago 23

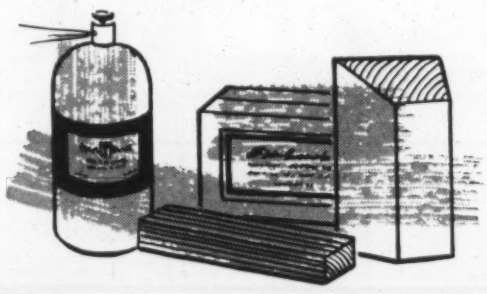
Your inquiry will receive prompt, professional attention from the chemical applications staff of the world's largest producer of CO_2.



☐ ▶ **Economical, Efficient "Freeze-Drying"**—Freeze-drying is used to dehydrate heat sensitive substances at low temperatures. In the processing of blood plasma and the manufacture of penicillin, streptomycin and other pharmaceuticals, dry ice or liquid CO_2 is used to freeze the item being dried. Also, during the drying stage, dry ice is used to condense the moisture as it is sublimed under vacuum. Capable of quickly attaining and maintaining the extreme low temperatures required, CO_2 has the added advantage of requiring only a small capital outlay.

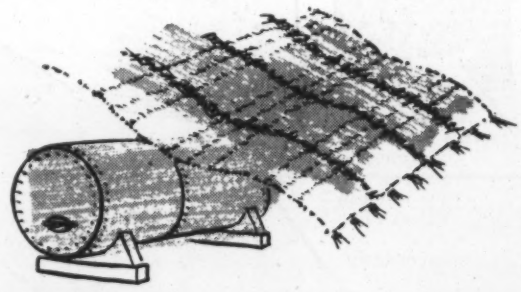


☐ ▶ **Curing Cores and Molds for Foundry Castings**—Ordinary foundry sand cores can be cured in 20 seconds flat, molds cured in an unbelievably short time. CO_2 gas reacting on a special sand binder gives an instantaneous chemical reaction ... eliminates baking, gives sound, hard, perfectly formed cores and molds of any shape or size. CO_2 curing gives more accurate dimensions, too. CO_2 cured molds can be left for several days before pouring.



☐ ▶ **Simplifies Pulverizing of Materials With Low Melting Point**—Many substances tend to melt or smear because of the heat generated in a milling process. DDT and vegetable fat flakes which are waxy and Teflon resin which is very tough and elastic are examples. In the low temperature pulverizing process the ingredient is mixed with crushed dry ice or low pressure carbon dioxide liquid is injected directly into the ingredient. These methods effectively inhibit the melting or smearing, prevents plugging and reduces horse power requirements. Gaseous carbon dioxide is also used to form an atmospheric "blanket" to effectively prevent fire during the grinding of flammable materials. An example of this application is the grinding of phosphorus pentasulphide and flammable resin materials.

☐ ▶ **Economical Gas Shielded Welding**—Costing only 1½ cents per cubic foot, CO_2 gas replaces expensive argon or helium gas in metal-arc gas shielded welding operations. Users report saving an average of 7 cents per cubic foot of gas. Low-cost CO_2 also produces welds that are equal, or superior, to welds made with argon or helium gas. No expensive installations are necessary ... present equipment can often be used "as is" or with modifications.



☐ ▶ **Effective Inerting Agent**—There are many times when an inert atmosphere is needed to prevent fire or explosion. Before welding a tank that has been used for the storage of flammable liquid, CO_2 is used to inert the atmosphere in the tank so that welding can be done with no danger of explosion. CO_2, acting as an effective atmospheric "blanket," also prevents oxidation and "skinning" of paints and oils.

SEND IN THIS PAGE FOR COMPLETE INFORMATION

Check off the applications which interest you, fill in the mailing information below, and mail this page to The Liquid Carbonic Corporation for prompt information. You'll also receive a free copy of our Booklet "Applications Unlimited," which covers dozens of other important uses for CO_2.

World's Largest Producer of CO_2
LIQUID CARBONIC
DIVISION OF GENERAL DYNAMICS CORPORATION
Chicago 23, Illinois

LIQUID CARBONIC
DIVISION OF GENERAL DYNAMICS CORPORATION
3172 South Kedzie Ave., Chicago 23, Illinois

NAME_____

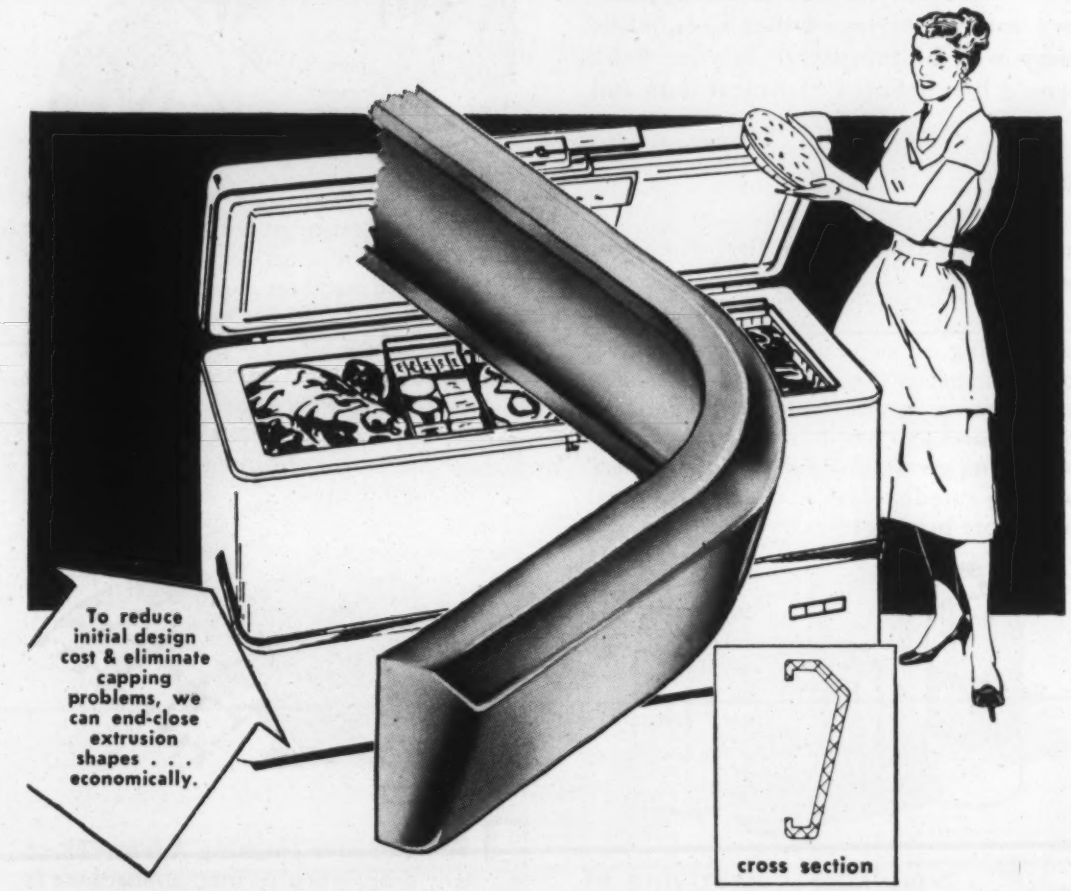
TITLE_____ **COMPANY**_____

ADDRESS_____

CITY_____ **ZONE**____ **STATE**_____

For more information, turn to Reader Service card, circle No. 518

LIGHT METALS CORPORATION CREATES NEW PRODUCTION ECONOMIES WITH *Extruded Aluminum*



Background illustration shows you how this trim part on a freezer cabinet is fully utilizing the latest developments in connection with extruded aluminum. The blown up inset gives you a better view of the end-closure.

We think its important that every one at all concerned with the designing and manufacturing of an end product should know about these new features:

1. END-CLOSURE is our own development and we are now able to close the ends of almost any extruded shape. The contour of the closure is limited only by our imagination. It gives you a beautifully smooth end . . . absolutely free from any damaging jagged, sharp or pointed ends.
2. SIMULATED CHROME FINISH. The above illustrated job demanded a very bright finish. With the new Bright Metal 6463 Alloy and with buffing and anodizing we produced a part that the average layman cannot tell from a chrome plated job. It's less money and it's much more permanent. This chrome like finish is a wonderful new addition to the many many other colors and textures already available to users of extruded aluminum.

We still have some samples of this job on hand and we would be glad to send one to anyone interested . . . as long as they last.

Just write, wire or phone

LMC LIGHT METALS CORPORATION

1217 Monroe N.W. Grand Rapids 5, Michigan

EXTRUDED ALUMINUM - COMPLETE FABRICATION FACILITIES - ANODIZING

For more information, turn to Reader Service card, circle No. 398

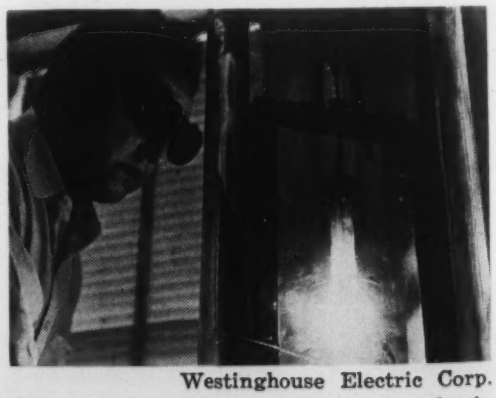
What's new IN MATERIALS

at pressures in the range of 500,000 psi for short periods of time. Later, a pressure chamber was built at GE to maintain for the first time temperatures well over 5000 F at pressures in excess of 1,500,000 psi for long periods. With this equipment and other apparatus developed since, diamonds are produced now in a matter of minutes on a pilot plant production basis.

Three Firms Develop Pure Columbium Metal

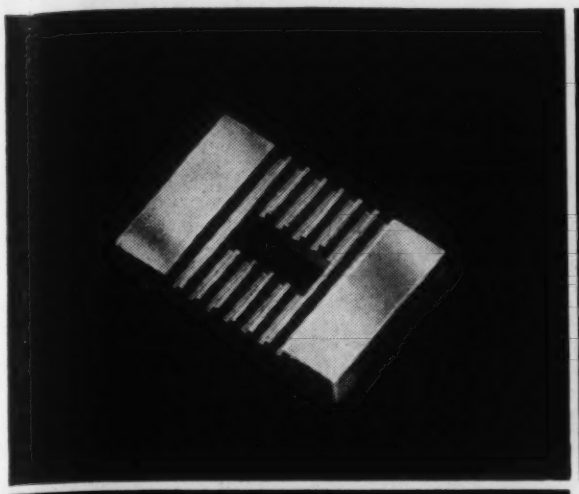
Three companies have recently announced the development of high purity columbium metal for possible use in high temperature alloys.

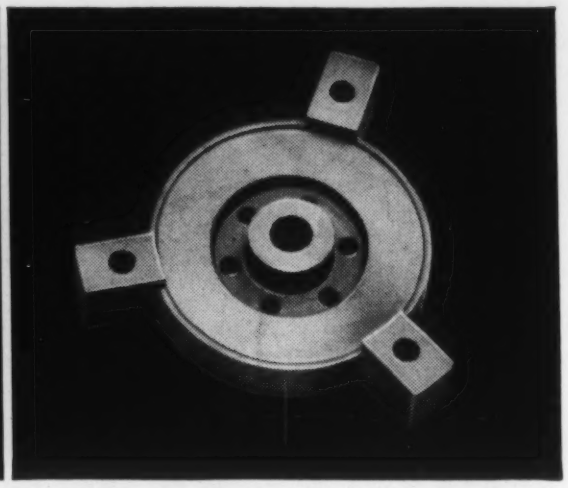
One company, Westinghouse Electric Corp., Box 2278, Pittsburgh, Pa., says it has developed a process that ". . . removes all but the very last traces of impurities in columbium by refining the metal at a white-hot temperature of almost 4400 F under a vacuum only four billionths the pressure of the atmosphere." Called "cage zone melting" the process melts a columbium bar from the inside out. The four corners of the bar do not melt, but form a "cage" within which the molten columbium is trapped. The columbium bar thus serves as its own crucible within which the white hot metal is refined. Westinghouse scientists are presently

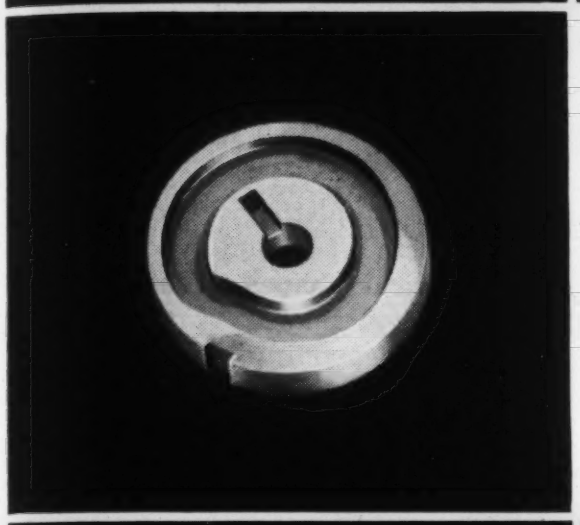


Westinghouse Electric Corp.

***Pure columbium** metal is made in this "cage zone melting" device.*



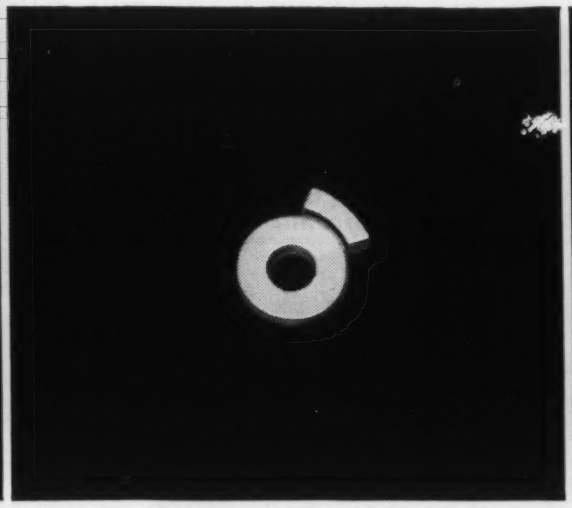




IN POWDER METALLURGY...

whether it's a slide for a door lock...or an air-conditioning valve plate

YOU CAN DEPEND ON YALE



Leading manufacturers have learned that the utilization of powdered metal parts in industry is practically limitless. But even more important than this —they have learned that for the *many* factors that influence successful production scheduling, *they can depend on YALE**.

First, there's *quality*. YALE powdered metal parts are built to specified strengths and accurate tolerances. The millionth part is as strong and as accurate as the first.

Then there's *quantity*. YALE has available large-scale production facilities to handle any size order.

There's imaginative *engineering*. Well qualified engineers work closely with manufacturers, advising them on the problems of powdered metallurgy.

Finally, there's *delivery*. A YALE schedule can be depended upon—production need never suffer because of delayed delivery.

America's foremost manufacturers have learned that, in powder metallurgy, they can depend on YALE. Perhaps you have a problem that can be solved by YALE dependability. Telephone us...we'd like to talk to you about it.

* REG. U.S. PAT. OFF.

THE YALE AND TOWNE MANUFACTURING COMPANY
POWDERED METAL PRODUCTS DIVISION
9335 BELMONT AVENUE, FRANKLIN PARK, ILLINOIS

powdered metal parts

YALE & TOWNE

For more information, turn to Reader Service card, circle No. 497

Prevent

CORROSION DISTORTION

with

morganite

SELF-LUBRICATING

VALVES, SLIDES and SEAL NOSES

GASOLINE PUMP VANE

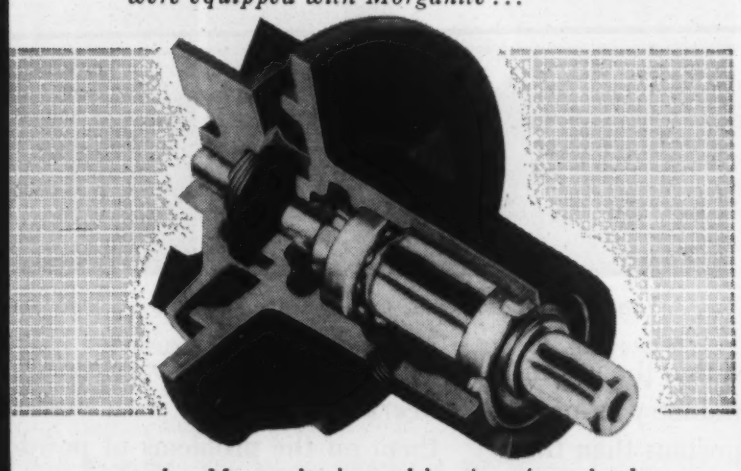
CRANE CURRENT COLLECTOR

DRUM CONTROLLER CONTACT

RADAR CONTACT

Eliminate failures—Due to swelling, warping, sticking and gumming. Morganite is chemically inert, imparts no taste, odor or colors—provides trouble-free operation in the presence of high temperatures and pressures, oil, water, corrosive chemicals, gases. Proven-in-service on food machinery, fuel pumps, liquid meters, compressors, enameling conveyors, jet engine pumps, pipe lines, process equipment.

Some of the first mechanical seal pumps using carbon seals, one of which is illustrated below, were equipped with Morganite ...



...today Morganite is used in aircraft and other modern pumps for trouble-free operation.

Designers! Engineers!—Morganite solves complex lubricating problems. Ask for complete information on Morganite Self-Lubricating Bearings, Pump Vanes, Gland and Piston Rings and other components. Morganite engineers will make recommendations on request.

Morganite TRADE MARK INCORPORATED

3324 48th Avenue
Long Island City 1
New York

... FOR OVER HALF A CENTURY

Manufacturers of Fine Carbon Graphite Products including Carbon Specialties, Motor and Generator Brushes, Carbon Piles, Current Collectors and Electrical Contacts; ***Distributors of*** 99.7% Pure Al_2O_3 Tubes and Crucibles.

For more information, turn to Reader Service card, circle No. 428

studying the strength of the metal at temperatures ranging from —320 to 2000 F. They are also studying high temperature oxidation and weldability of the metal.

The second company, Electro Metallurgical Co., 30 East 42nd St., New York 17, says it is producing "columbium metal melting stock of the highest purity ever made." The metal, available in limited quantities, is produced in the form of roundels and small cylindrical shapes. The company says the metal sells for $55 to $80 per lb depending on shape and form desired.

The third company to announce development of high purity columbium is Fansteel Metallurgical Corp., 2200 Sheridan Rd., North Chicago, Ill. Fansteel officials say ". . . supplies of pure columbium are now available and deliveries are substantially improved." The metal is available from Fansteel in the form of sheet, rod, seamless and welded tubing and fabricated parts.

Degassed Resins Make Better Plastics Parts

Voids, pits and surface imperfections in molded reinforced polyester resins are said to be practically eliminated when the resin is degassed before mixing with reinforcing agents. Recent studies show that the greater the air dissolving capacity of a resin, the more air it absorbs during mixing. Since the resin becomes partially saturated with air during mixing, it loses its ability to dissolve air bubbles displaced from the glass fiber mat and cloth during the molding process. These bubbles are thought to be responsible for voids, pits and surface imperfections formed in the final molded product.

In order to overcome this problem of air entrapment, Hull Corp., Hatboro, Pa., is making available

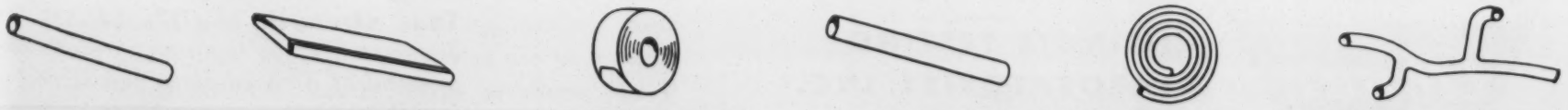
"Must be glorious tubing, eh comrade? Just before we are leaving, the commissar he says to me, 'Ivan . . . if, you dunt get pictures we are needing to make tube just like H & H Lockseam, dunt bother coming back'."

Expect the BEST brass and copper products from

H&H TUBE AND MANUFACTURING CO.

252 *N. Forman Avenue, Detroit 17, Michigan • Offices from Coast to Coast*

Heating and cooling components, stationary or mobile, last longer when quality is built in with world famous H & H Lockseam. Oval brass Lockseam comes in 48 sizes, round brass Lockseam in sizes from 5/16" to 3/8". Solder coated on the outside or both sides, this strong edge seam tubing is cut to customer specifications or furnished in random lengths.



METALFLO LOCKSEAM COIL STRIP SEAMLESS TUBING TUBULAR PARTS

For more information, turn to Reader Service card, circle No. 515

detect

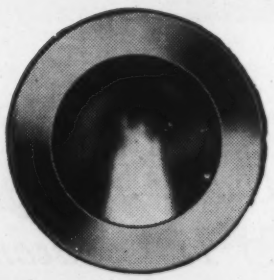
- restricted flow of atmosphere
- leaky furnace seals
- transient moisture and air from quench tank
- air carried into the furnace with the charge

with the DEWPOINTER

Quick and accurate readings of dewpoints in each furnace zone give the heat treater the most valuable information possible for accurate adjustment of furnace atmosphere.

In one relatively inexpensive unit, the Dewpointer brings you this accurate data with simple operations. Any shop man can get precise readings every time—for the maximum in effective furnace control.

Only the Alnor Dewpointer gives you controlled test conditions...indications take place in an enclosed chamber. Dew or fog is suspended in the air as sunbeams —not on a polished surface. This unique principle gives you the greater accuracy, faster readings required for critical heat treating atmosphere control.

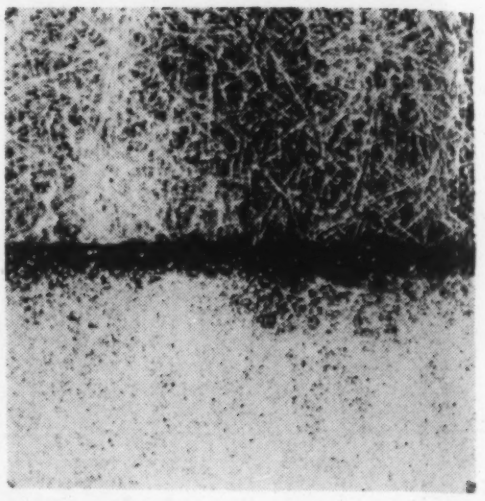


Eliminate Guesswork
Here's what you actually see with a Dewpointer—a swirl of sunbeams that is unmistakable in reading. Find out why so many use the Dewpointer for atmosphere control. Send for your copy of the illustrated Dewpointer Bulletin. Write: Illinois Testing Laboratories, Inc., Room 522, 420 North LaSalle Street, Chicago 10, Ill.

Alnor

ILLINOIS TESTING LABORATORIES, INC.

For more information, turn to Reader Service card, circle No. 410

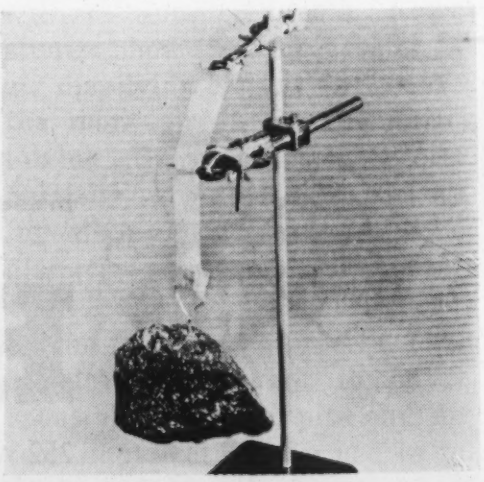


Molded sheet *of degassed polyester resin (top) compared with sheet (bottom) that has not been degassed.*

specially designed equipment for commercial scale degassing of polyester resins. The equipment is claimed to restore to the resin its capacity for dissolving air. Essentially, the degassing system consists of a large vacuum type kettle equipped with a sight glass, a manometer and a vacuum gage.

High Strength Silicone

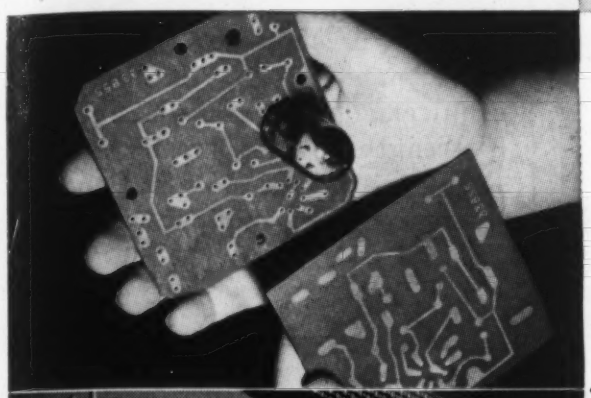
General Electric Co., Silicone Products Dept., Waterford, N. Y., has announced the commercial availability of a high strength silicone rubber compound developed earlier this year (see MATERIALS & METHODS, May '57, p



Tear strength *of GE's SE-555 is demonstrated by hanging a weight on one end of a cured strip and stretching it against a razor blade.*

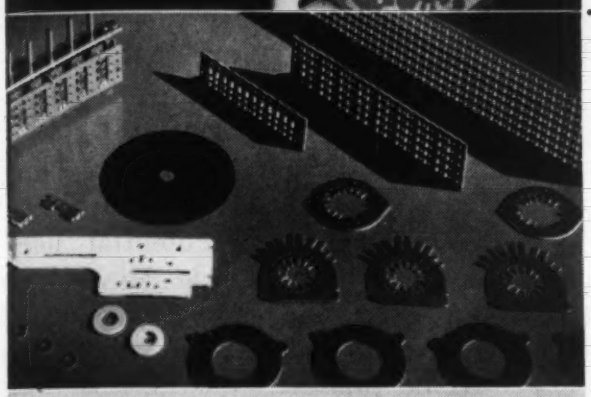
RICHARDSON — plastics for electronics

. . . laminated—molded



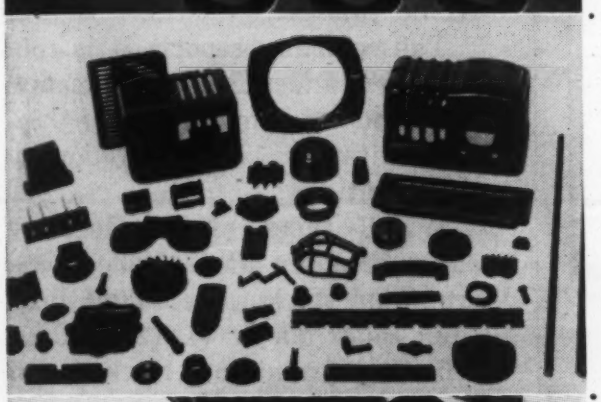
COPPER-CLAD INSUROK

Choice of various grades. Copper bonded to one or both sides. Outstanding electrical properties after humidity conditioning. High flexural and tensile strength. Holds metal inserts and lugs securely. Excellent bond strength and heat resistance.



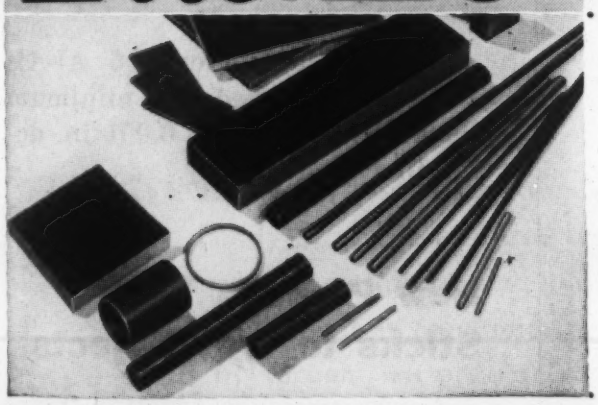
FABRICATION

Complete facilities for punching or machining precision parts from laminated INSUROK to your specifications in any quantity—for electrical or mechanical applications.



MOLDED PLASTICS

Parts molded from standard or special plastics materials as required for your product, including newest plastics. Produced by compression transfer or injection processes. Metal inserts molded in position.



LAMINATED INSUROK

Available in sheets, rods, and tubes in NEMA and special grades. Properties to meet practically any electrical or mechanical requirements. Many sizes and thicknesses.

technical services

Experienced Richardson engineers will analyze your requirements and help you select the material, and best manufacturing process for your needs . . . and when your requirements are unusual, Richardson offers extensive background for developing special plastics materials for your product. Also, Richardson is equipped to provide complete facilities and techniques for molding, laminating, molded laminates, and fabricating. You are assured the correct material and process for each application. These research, design, and engineering services are yours without cost or obligation, of course. Write or phone, today.

Write for 12-page booklet
"INSUROK® Laminated Plastics—Molded Plastics"

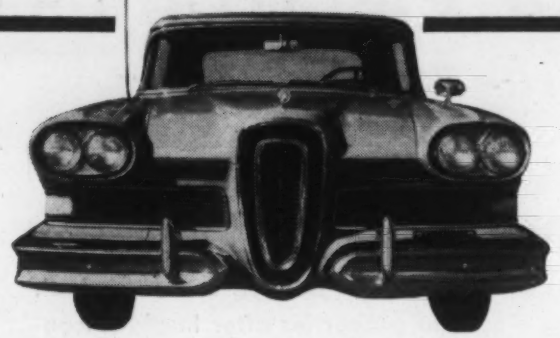
The RICHARDSON COMPANY

LAMINATED AND MOLDED PLASTICS

Dept. 16, 2637 Lake Street
Melrose Park, Ill.

For more information, turn to Reader Service card, circle No. 496

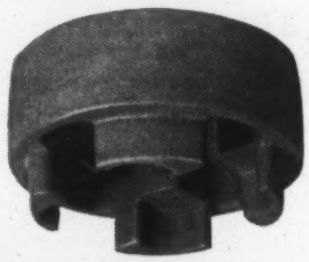
How about Malleable?



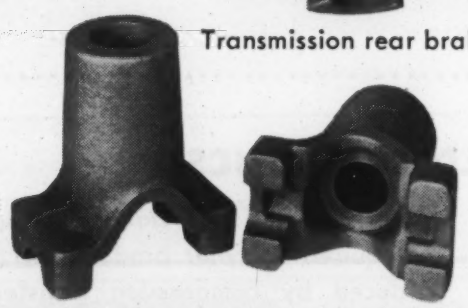
The 1958 Edsel

America's Newest Automobile includes Malleable Iron Castings as important components

Power steering housing



Transmission rear brake drum



Universal joint flange

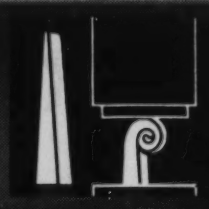
Recognized for its durability and versatility for over 130 years, and used for parts in all kinds of transportation equipment, it's not surprising to find applications of standard and pearlitic Malleable castings throughout the Edsel.

The three Edsel parts examples illustrated are important uses of malleable. The power steering mechanism housing is certainly a place for safety insurance. The universal joint flange is a vital link in the power train. And the transmission rear brake drum helps complete the flow of engine power to the car's drive wheels.

It's very likely *your* product could be strengthened, lightened or improved by the use of malleable iron castings. And malleable's easy machinability speeds production and cuts costs. A helpful review of *all* malleable iron advantages is contained in our new publication "Value Analysis". Write for your copy — to the Malleable Founders' Society.

Consult a malleable foundry engineer at the drawing board stage.

Malleable FOUNDERS' SOCIETY



1800 Union Commerce Building Cleveland 14, Ohio

For more information, turn to Reader Service card, circle No. 550

187). Designated SE-555, the compound meets AMS 3345 requirements for tensile and tear strength, elongation, dry heat resistance, compression set and low temperature flexibility.

Titanium Foil

Titanium foil is now commercially available from General Plate Div., Metals & Controls Corp., Attleboro, Mass. This is believed to be the first time titanium alloys have been successfully rolled into foil thicknesses. Potential uses for the foil include honeycomb sandwich constructions, diaphragms and bellows, and electronic tubes.

The company reports it is rolling and annealing experimental and production quantities of thin-gage titanium in the following classifications:

1. All types of commercially pure titanium alloys, rolled to a minimum thickness of 0.001 in.
2. Beta alloys (B-120 VCA), rolled to a minimum thickness of 0.002 in.
3. Alpha-beta alloys (6 Al-AV and others), rolled to a minimum thickness of 0.003 to 0.001 in. depending on the alloy.

New Plastics Tape Sticks to Wet Objects

A new pressure sensitive plastics tape, similar in appearance to cellophane tape, has been developed by Mystik Adhesive Products, Inc., 2635 N. Kildare Ave., Chicago. Called Kylon, the tape is claimed to have impact resistant properties nine times higher than those of cellophane tapes. In addition, the tape is said to adhere to damp surfaces indefinitely and to retain the same tensile strength after prolonged soaking as it possesses when dry.

The tape is said to have a ten-

WHY CYCOLAC® HIGH IMPACT THERMOPLASTIC RESIN in the MERRIMAN outboard steering pulleys?

. . . the answer is simple! . . .

Merriman Brothers Inc., of Boston, Mass., chose CYCOLAC for their boat pulleys after exhaustive tests conclusively proved CYCOLAC to be ideally suited for pulley sheaves. CYCOLAC has much higher impact strength; will not absorb moisture . . . allows an accurate tolerance between sheave and shaft. In addition, CYCOLAC is self lubricating and unaffected by oils, gasoline, intense sun or salt water.

CYCOLAC can also work wonders for you. This family of single uniform resins is permanently thermoplastic, permitting fast molding, calendering and extruding. It is economical to form press-polished sheets by vacuum, air-pressure, or mechanical methods over inexpensive molds of wood, plaster, aluminum, etc.

Write for technical literature today!

molders • extruders • calenderers

Compare these added CYCOLAC Benefits!

In addition CYCOLAC's unique balance of properties, which makes it ideal for hundreds of end-use products, you get these added benefits!

- No breakage in processing.
- No breakage in assembling and finishing operations.
- Better adherence to dimensions and tolerances.
- Readily lacquered, enameled or printed. Decals apply easily.
- Greater uniformity of processing.
- Lower shipping costs.
- Light weight means more parts per pound.

PACESETTER IN **Marbon CHEMICAL** SYNTHETIC RESINS

Division of BORG WARNER • Gary, Indiana

also represented by:

WEST COAST: Harwick Standard Chemical Co., Los Angeles, Cal.
CANADA: Dillons Chemical Co. Ltd., Montreal & Toronto
EXPORT: British Anchor Chemical Corp., New York

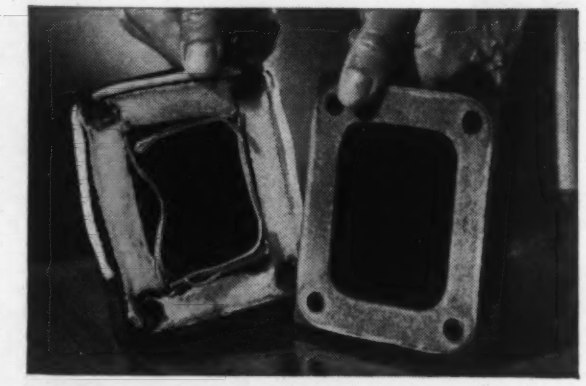
For more information, turn to Reader Service card, circle No. 524

IS NOT ATTACKED BY FUMING NITRIC ACID

Reinforced Teflon (DUROID 5600) showed no sign of attack after 48-hour immersion in Type IIIA fuming nitric acid at 80°F.

DOES NOT COLD FLOW UNDER PRESSURE

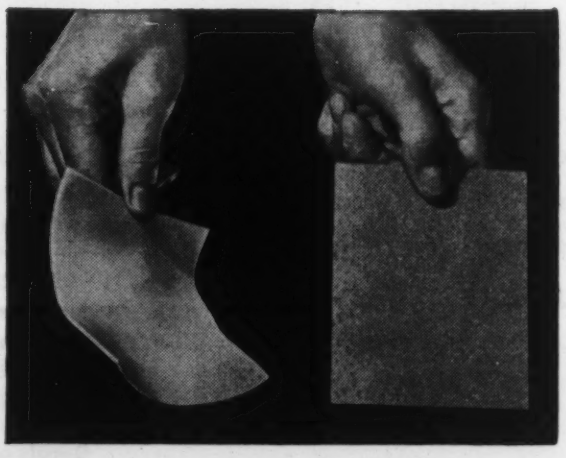
Reinforced Teflon (DUROID 5600) at right resisted torque and flange pressure that caused extrusion of Teflon.



REINFORCED TEFLON*
(DUROID 5600)
INDICATED FOR CRITICAL GASKET USE

GREATER RESISTANCE TO HEAT DISTORTION

Teflon (left) distorted badly when subjected to 720°F. and then cooled. Reinforced Teflon (DUROID 5600) retained flatness.



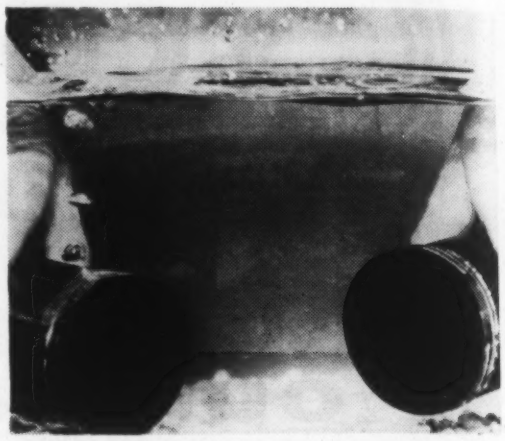
Rogers makes several grades of reinforced Teflon under the designation DUROID 5600 series. One of these grades may be just the material you need for a critical gasket application. Please write Dept. M for technical data.

*Registered trademark of DuPont Company for its tetrafluoroethylene resin.

ROGERS CORPORATION ROGERS CONNECTICUT

DUROIDS • SHOE MATERIALS • ELECTRICAL INSULATION • PLASTICS • RUBBER • FABRICATING • DEVELOPMENT

For more information, turn to Reader Service card, circle No. 433



Kylon plastics tape *(right) adheres to a cylinder held under water for more than 30 min, whereas a cellophane tape (left) loses tack and begins to peel.*

sile strength of 22 lb per in. and a water absorption value of 0.05% max. It is said to maintain optimum adhesion at temperatures ranging from 122 to 140 F, and is said to resist temperatures up to 180 F for extended periods.

The tape can be used as printed labels in inventory and control operations. It can also be used for sealing, bundling, mending, bonding, splicing and fastening applications. It is supplied 0.0023 in. thick and ¼ in. wide.

Solder for Aluminum Checks Corrosion

A simple and effective technique for soldering aluminum and its alloys as well as galvanized metals has been developed at Bell Telephone Laboratories. The technique, using an inexpensive and stable zinc-base alloy and no flux, is most effective in joining butt and Tee joints. The zinc-base alloy is said to check intergranular corrosion of soldered aluminum parts because it contains no lead, tin, bismuth or cadmium.

According to G. M. Bouton and P. R. White, developers of the process, it is not necessary to remove rolling mill oils or surface oxide when soldering aluminum with the new process. They say,

Hydroforming

a deep drawing and forming service without costly dies

saves up to 90% on tooling costs... speeds model development work... allows unequalled design freedom... saves on short and medium production runs.

These parts are typical of the hundreds of parts of all shapes and complexities that have been produced by the Hydroforming Company of America. This versatile, economical form of simplified deep drawing combines extreme precision in deep drawing with low cost tooling and fast parts delivery. While showing to its best advantage on medium and smaller production runs, **it can and does** produce parts that are impossible to produce by any other method.

Hydroforming can often produce spectacular results in forming prefinished parts—reducing delivery times—cutting costs. One manufacturer cut production time **by 90 days and reduced tooling costs over $30,000.00.**

Do you have a part that can be Hydroformed?

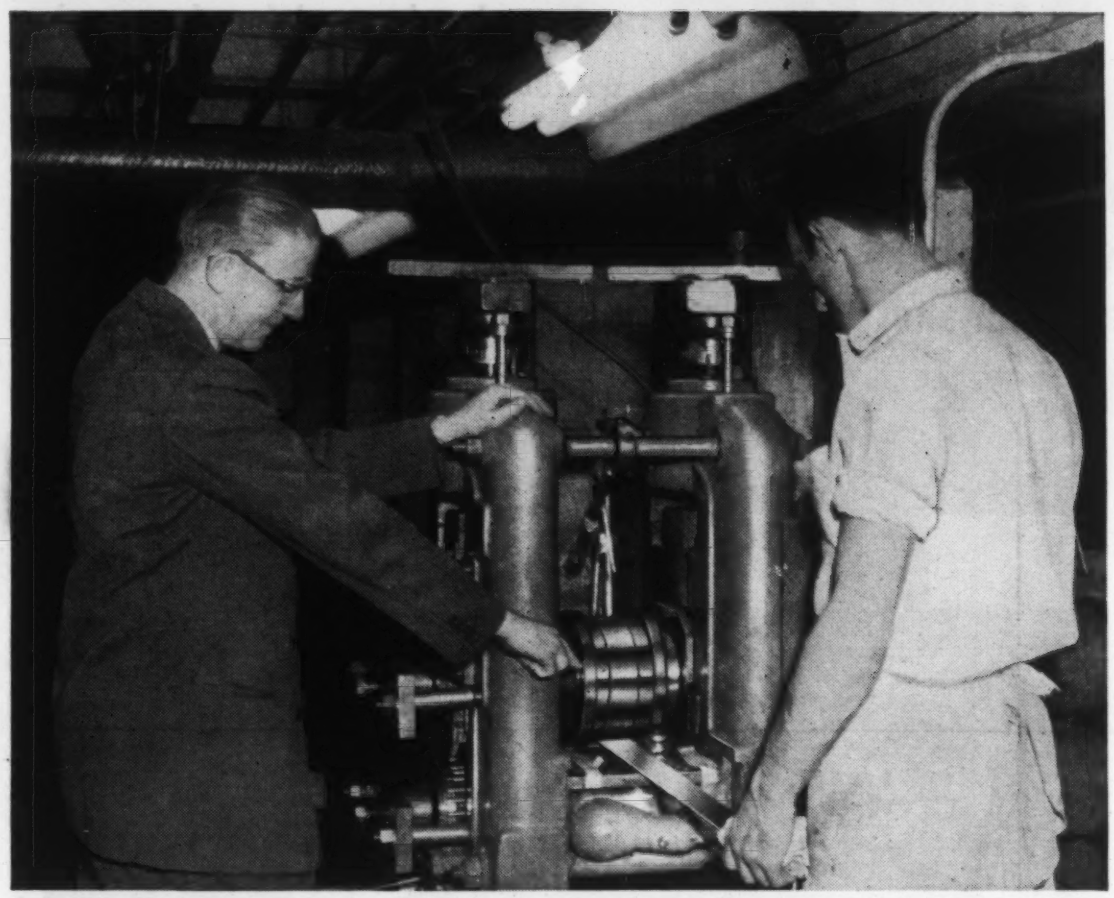
Write, wire or call for details, or send your prints for estimates—in strictest confidence of course.

Hydroforming Company of America

7406 W. Lawrence Ave., Chicago 31, Illinois PHONE: UNderhill 7-7600

For more information, turn to Reader Service card, circle No. 385

Proof of Vulcan Tool Steel Superiority



Cold rolling of critical heat resisting alloy stator vanes at D.E. Makepeace Company, Attleboro, Mass.

Vulcan Service PLUS TCM Steel solves tough rolling problem on jet stator vanes

Vulcan sales engineers, working closely with the tool experts of D. E. Makepeace, faced a tough and exacting problem: How to increase the service life of rolls used in cold rolling critical jet engine heat resisting alloy stator vanes.

As a result of joint investigations, design changes were recommended and adopted. The result? Roll life was multiplied.

Vulcan engineers went further. Despite the fact that other grades of tool steel had been tried and found unsatisfactory, Vulcan engineers predicted that *additional* improvements could be made by using Vulcan TCM steel. This recommendation, too, was adopted. The result? The already increased roll life was *trebled*. Net result: substantial savings with increased roll life, less down time and greater productivity.

This same engineering help is available to you without charge. For the name of your nearest Vulcan representative, write, wire or call collect. Vulcan Crucible Steel Division, H. K. Porter Company, Inc., Aliquippa, Pa.

H. K. PORTER COMPANY, INC.

VULCAN CRUCIBLE STEEL DIVISION

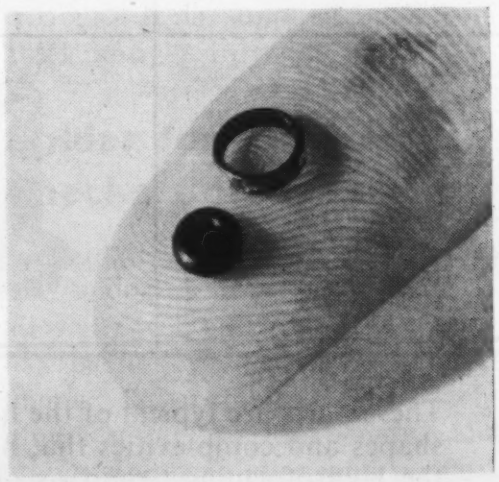
For more information, turn to Reader Service card, circle No. 402

What's new IN MATERIALS

"A single stroke of the solder stick across a heated aluminum surface will cause it to penetrate the oxide and wet the aluminum. The normally tenacious oxide film is lifted off much like paint peeling from wet wood; this raised oxide coating may then be wiped aside. Surfaces thus wet can be joined by bringing them together and adding more solder by drawing the solder stick across the hot metal pieces."

Plywood-Resin Sheets Resist Heat, Moisture

Two plastics and wood products —a fiberglass-reinforced resin bonded to plywood, called Lamiclad, and a phenolic resin bonded to plywood, called Lami-line—are available as liners for commercial cold storage rooms, freight cars, trucks and tractor trailers. Developed by Strick Plastics Co.,



Small rubber parts — The tiny o-rings shown above have an i.d. of 0.042 in. and a cross section of 0.050 in. According to the producer, E. F. Houghton & Co., 303 W. Lehigh Ave., Philadelphia 33, the small rubber parts are made in lots of 50,000, with each part falling within dimensional tolerances. The rubber used in the parts is said to have good physical and electrical properties and good oil resistance.

CYLINDRICAL APPLICATIONS:

UNLIMITED

Sandusky Centrifugal Castings offer you 4 Important Advantages

1. Superior mechanical properties to meet exacting design requirements
2. Uniform soundness—free from harmful inclusions and porosity
3. Highest quality—to insure long, dependable, trouble-free service
4. Job-ready castings—machined to your exact specifications

More and more design engineers are realizing that new applications for centrifugal castings are *unlimited* . . . thanks to new knowledge about alloys . . . new casting and machining techniques and facilities.

From simple bushings to atomic reactor components . . . from bronzes to heat, corrosion, and abrasion resistant stainless steels . . . from 7″ to 54″ O.D. and lengths to 33 ft.—Sandusky centrifugal castings are providing gratifying results in scores of applications, many unheard of a few years ago.

What cylindrical or piping problem can we help you solve? . . . Code pressure vessels? . . . Reactor vessels? . . . Power Piping? . . . What is your problem?

Your inquiry will bring more information promptly . . . or, if you prefer, a personal call by one of our engineers.

CENTRIFUGAL CASTINGS

Sandusky Foundry & Machine Company

SANDUSKY, OHIO • *Stainless, Carbon, Low Alloy Steels—Full Range Copper-Base, Nickel-Base Alloys*

For more information, turn to Reader Service card, circle No. 434

What you ought to know about deep drawn shapes and shells

Hackney deep drawn shapes and shells permit product designers to reduce weight, save production time and lower unit costs—improve product appearance, increase strength and vibration resistance. Our experience in producing O.E.M. parts for manufacturers of many types of equipment can help you achieve similar results. Just keep these basic specifications in mind:

Shapes: Cylindrical, spherical, tapered or conical.

Capacities: From 1 quart to 70 gallons.

Diameters: From 3 inches up to 32 inches.

Depths: Up to 60 inches. Two half shells are easily welded together for extra length or symmetrical design. Open end can be closed by spinning to give an entirely seamless cylinder.

Blank thicknesses: 16 gauge and heavier.

Wall thickness: For working pressures up to 5,000 psi in the smaller diameters—up to 200 psi in the larger diameters.

Metals: Steel, stainless steel, nickel, aluminum, magnesium, copper and many alloys.

Write for details.

Pressed Steel Tank Company

Manufacturer of Hackney Products

1442 South 66th Street, Milwaukee 14, Wisconsin

Branch offices in principal cities

CONTAINERS AND PRESSURE VESSELS FOR GASES, LIQUIDS AND SOLIDS

For more information, turn to Reader Service card, circle No. 414

What's new IN MATERIALS

Perkasie, Pa., the products are available in 4 by 8-ft sheets in thicknesses from ⅛ to 1½ in.

Both Lami-clad and Lami-line are said to have good impact resistance and good resistance to vermin, grease and odors. Both products can be steam cleaned without warping or absorbing moisture.

Flat Borosilicate Glass

A flat borosilicate glass featuring good resistance to thermal shock and chemicals has been introduced by Blue Ridge Glass Corp., Kingsport, Tenn. The producer says the flat product under proper conditions can be used continuously at temperatures approaching 900 F. The flat glass product is particularly suited for oven door glasses, furnace sight glasses, cooking sheets, splash plates and heat shields.

Black Nylon Resin for Outdoor Uses

A new nylon resin, said to combine mechanical toughness with good resistance to heat and weathering, has been developed by E. I. du Pont de Nemours & Co., Inc., Wilmington, Del.

Called Zytel 37X nylon resin, it is designed primarily as a jacketing material for power and communications cables, wire rope, service drop wire and tree wire. Other uses anticipated for the nylon resin include marine hardware, and mechanical devices exposed to weathering.

Du Pont says the resin, a black molding and extrusion powder, is specially compounded with heat and light stabilizers. Accelerated heat and light tests indicate that the resin has better heat and weather resistance than any other nylon, according to the producer.

(continued on p 196)

Goodyear Aircraft Corporation specifies "SCOTCHPLY" Reinforced Plastic

...for Air Force 26½ foot rigid radome

Air Force design and specifications were clear: Material for this rigid radome must meet precise electrical requirements in addition to being structurally strong, lightweight and with high modulus. That's why Goodyear Aircraft Corporation recommended "SCOTCHPLY" Brand Reinforced Plastic.

Goodyear knew the "SCOTCHPLY" Reinforced Plastic story. They knew that the tremendous flexural modulus and strength of "SCOTCHPLY" Reinforced Plastic would enable them to construct a superior 26½ foot radome—one which would eliminate bulky trusswork previously utilized in rigid radomes of comparable size. They knew that the elimination of this bulky trusswork would minimize radar interference and result in greatly improved transmission efficiency.

Goodyear—and "SCOTCHPLY" Reinforced Plastic—got the job.

"SCOTCHPLY" Reinforced Plastic is a high-strength, moldable, laminated structural plastic reinforced with *continuous, non-woven* glass filaments. These reinforcing filaments can be accurately oriented to meet specific stress requirements. For example, at 70° F., unidirectional "SCOTCHPLY" Reinforced Plastic has a flexural strength of 130,000 psi and a flexural modulus of 5.3×10^6 psi. For complete information on this remarkable new material and what it can do for you, write 3M, Dept. PB-127, St. Paul, Minn.

REG. U. S. PAT. OFF.

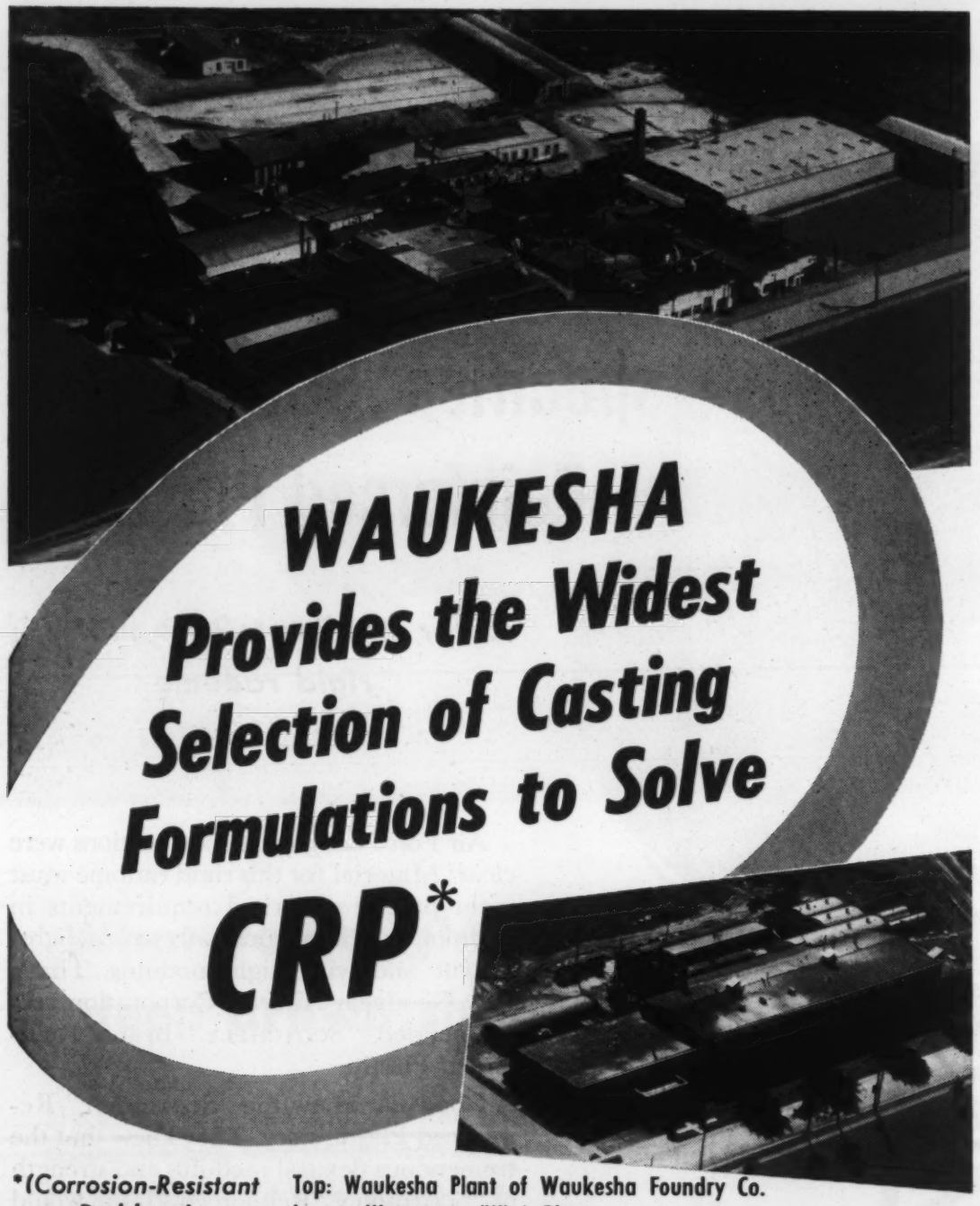
SCOTCHPLY Reinforced Plastic

BRAND

3M COMPANY

THE TERM "SCOTCHPLY" IS A REGISTERED TRADEMARK OF MINNESOTA MINING AND MANUFACTURING COMPANY, ST. PAUL 6, MINN. EXPORT SALES OFFICE: 99 PARK AVE., NEW YORK 16, N.Y. IN CANADA: P.O. BOX 757, LONDON, ONTARIO.

For more information, turn to Reader Service card, circle No. 542



WAUKESHA Provides the Widest Selection of Casting Formulations to Solve CRP*

*(Corrosion-Resistant Problems)

Top: Waukesha Plant of Waukesha Foundry Co.
Lower: Watertown (Wis.) Plant

Corrosion-resistant characteristics in castings have never been resolved to a common denominator for all chemicals, all temperatures, all products — and, it is likely, never will. Further complications enter with tensile, weight and elongation specifications. Those are reasons why — unless you *know* you have already found the perfect, unimprovable solution — your source for corrosion-resistant castings should be a foundry so versed in alloys and special deviations that its metallurgical and research laboratories have the greatest possible likelihood of attaining the most nearly perfect answer.

WAUKESHA is that foundry.

And even if you *know* you have the perfect metallurgical solution, your source for castings should be a foundry with high production facilities — yet so versatile that only *one* casting is welcome — and where through constant metallurgical analyses from ingots to pours — uniformity in all characteristics is absolute.

Again, WAUKESHA is that foundry.

Basics in the metals WAUKESHA offers:

Stainless Steel (300 to 400 series) — Monel — Inconel — Pure Nickel — Ni-Resist — Brass — Copper — Aluminum — and all special deviations in formulations. In addition WAUKESHA has been granted patents on several alloys because of their unique characteristics in performance, non-corrosion as well as non-galling.

WAUKESHA FOUNDRY COMPANY

5704 Lincoln Avenue

WAUKESHA • WISCONSIN

For more information, turn to Reader Service card, circle No. 563

What's new IN MATERIALS

Rubber Gaskets, Seals Resist Gases, Naphtha

Gaskets and o-rings made of a synthetic rubber compound especially designed for sealing gas and other petroleum derivatives are now commercially available from Minnesota Rubber & Gasket Co., 2630 Wooddale Ave., Minneapolis, Minn. The compound, designated 503 A, has been approved by Underwriters Laboratory for use with gas, kerosene, naphtha and LP gas in both the gaseous and liquid states at temperatures from 30 to 125 F.

Copper Bath Gives Bright Electroplates

Brighter copper electroplates than presently available are possible by using a new copper cyanide plating bath process.

Developed by Metal & Thermit Corp., Rahway, N. J., the plating bath contains a brightener called Neochel that is said to reduce plating costs, speed up plating time and simplify bath control. The additive is also said to reduce anode corrosion and to minimize rough copper deposits on metal parts. According to the company, the plating bath can be

***Plating process** is said to produce bright copper electroplates at high current densities.*

CASE HISTORIES FROM
MT. VERNON FILES

RONSON produces the First Electric Shaver with 2 Separate Cutting Heads

Ronson calls their new "66" Shaver "the most revolutionary electric shaver ever designed"—and offers strong evidence to support this claim. For one thing, it is the first electric shaver with an *extra* cutting head, called "Super Trim", which does every trimming job, from sideburns to mustache.

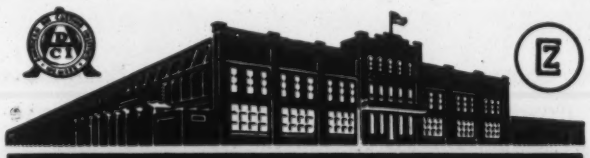
When any manufacturer is out to break precedent, and still sell his product at a competitive price, he needs every bit of designing and production skill he can find—anywhere.

Ronson found these in generous abundance at Mt. Vernon. Three of the vital parts of the "66"—the head frame and the plate covering the "Super Trim" blades (zinc castings), and the motor chassis (an aluminum casting)—were designed to obtain the special advantages of die casting: thin wall sections of great strength and rigidity, negligible machining, smooth finish, high speed production, low cost.

Says Ronson: "These parts are highly vital to our electric shaver. The cutting mechanism depends on the head frame for its accuracy of mounting and rigidity while cutting. The chassis on which the motor is built is of course the heart of the shaver's power system, and a very accurate casting is necessary for the job."

These advantages, important to any manufacturer, stem directly from the way we are organized here at Mt. Vernon. We have both the facilities and the complete die casting service it takes to produce parts like these, in any quantity, at minimum cost. We have 200,000 square feet of the most modern equipment for making dies and for die casting aluminum and zinc. And Mt. Vernon service comprises completely coordinated designing, die-making, casting, and machining, all under one roof.

It will pay you well to bring your production specifications to us. We may show you, as we did Ronson, the way to important cost reductions and improved products.



MT. VERNON
DIE CASTING CORP.
STAMFORD, CONNECTICUT

SALES REPRESENTATIVES

STAMFORD, CONN.—Mr. Anker Anderson, Cascade Road
GUILDERLAND, N. Y.—Mr. David H. King, 75 Willow St.
BALTIMORE, MD.—Carey & Gordon, 919 St. Paul St.
CLEVELAND, OHIO—Mr. Grant Eller, 6 East 194th St.
EAST ORANGE, N. J.—Mr. George E. Hahl, 37 So. Munn Ave.
ROCHESTER, N. Y.—Mr. William Sauers, 101 Braircliff Rd.
SKANEATELES, N. Y.—Mr. Jerome J. Theobald, 9 E. Genessee St.
BALA-CYNWYD, PA.—Mr. G. T. Mc Master, Llanberris Apts., C-1
BOSTON, MASS.—Mr. James Cleary, 61 Exeter Street

For more information, turn to Reader Service card, circle No. 415

700 PARK CLOSED-DIE FORGINGS

. . . Wt. 2750 Lbs. Ea.

SAVE MACHINING TIME
Eliminate
"POROSITY REJECTS"

for manufacturer of automotive glass-making machinery

A Park sales engineer showed this manufacturer of an automated glass-making line how to save money by using large, closed-die forgings. These Park closed-die forgings were closer to being completed parts—needed a minimum of final machining. Uniform in quality, they required less inspection. And there was no danger of investing expensive machine time in parts—then have them rejected because they contained "blow-holes" or porosity defects.

One of the largest production runs of closed-die forgings ever scheduled for the machine tool or machinery field, these 700 forgings, each weighing 2750 lbs., were produced in Park's shops in record time.

Let our sales engineers show you how a Park closed-die forging can cut down machine time and rejects—increase strength and safety on your product requirements.

Die Forging Specialists Since 1907

THE PARK DROP FORGE CO.
775 EAST 79TH ST. • CLEVELAND 3, OHIO

Carbon, Alloy, Heat-Resistant Alloy, and Stainless Steel Closed-Die Forgings from 5 lbs. to 5000 lbs.

For more information, turn to Reader Service card, circle No. 521

What's new IN MATERIALS

operated at current densities ranging from 10 to 60 amp per sq ft without burning the edges of the electroplate. The process is said to be applicable to automatic, still and barrel plating operations.

Modified Polystyrene for Towel Racks, Toys

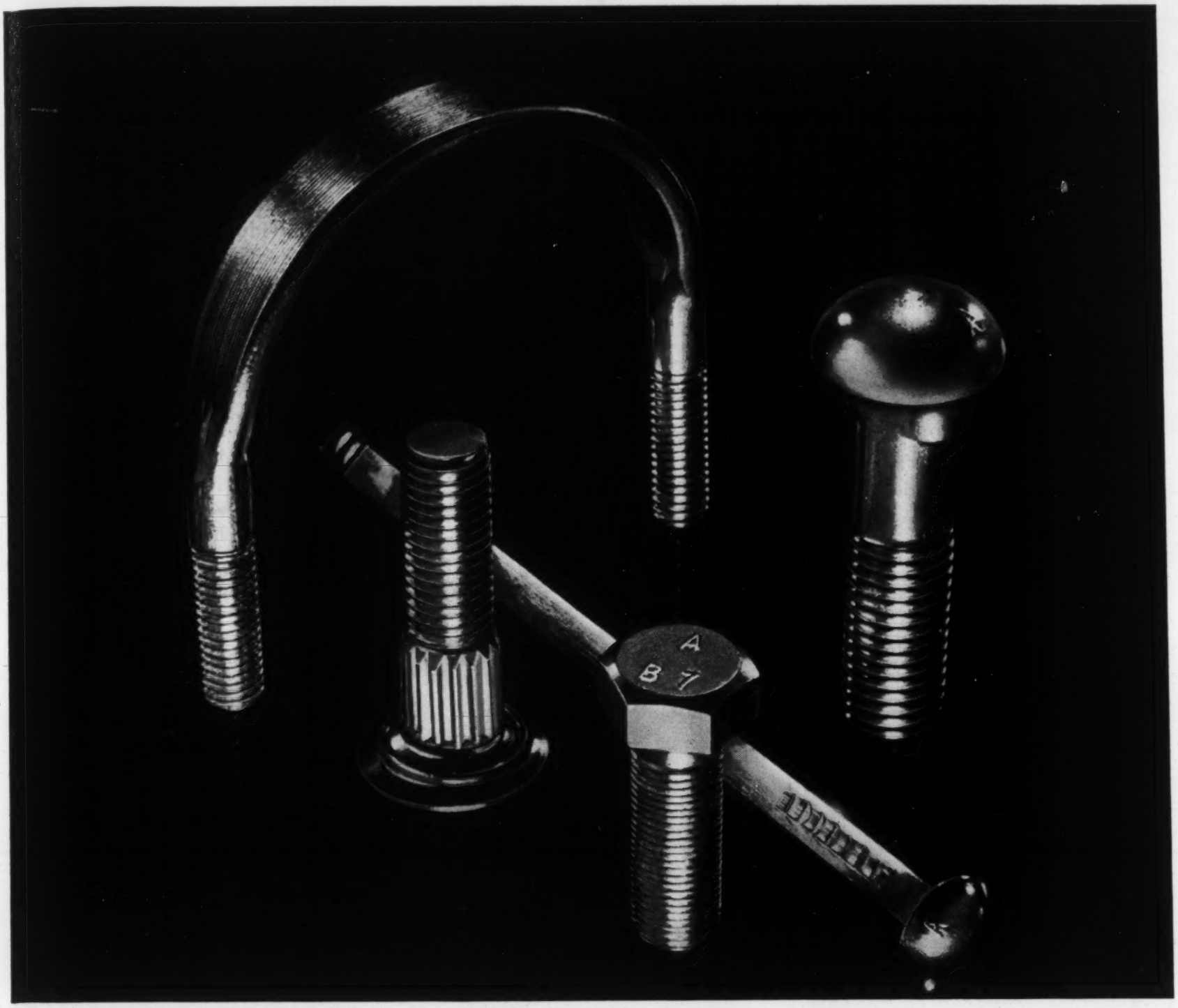
A medium impact, rubber-modified polystyrene molding compound is now available from Bakelite Co. Div., Union Carbide Corp., 260 Madison Ave., New York 16. Designated TMDA-8020, the molding compound is said to have the same color stability, chemical resistance and electrical properties as rubber-modified high impact styrenes, together with molding properties similar to those of rubber-modified, general purpose polystyrenes. TMDA-8020 has a specific gravity of 1.04, a tensile strength of 4300 psi and a flexural modulus of 6900 psi.

The molding compound is recommended for detergent closures, container parts, switch plates, towel racks and action toys.

Coated Magnet Wire Meets Class F Spec

A polyester film-coated magnet wire, offered under the Class F (310 F) rating established by the AIEE, is being marketed by Anaconda Wire & Cable Co., Muskegon, Mich. According to the producer, the wire also complies with Underwriters Laboratories requirements for magnet wire used in Class B motors and transformers.

The coated wire is said to have good thermal and chemical stability, excellent abrasion resistance, and good dielectric strength. It is available in single and heavy film thicknesses in AWG sizes from 15 through 25.



Good Delivery on Electroplated Fasteners

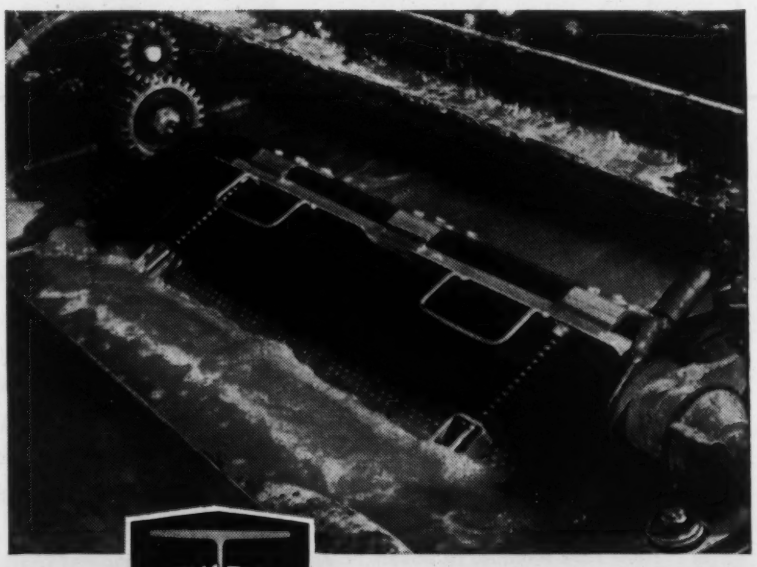
Any time your products call for electroplated fasteners —either bright-zinc-plated or cadmium-plated—get in touch with Bethlehem.

Bethlehem electroplated fasteners have a smooth, good looking finish. They meet ASTM Specifications A 164-55 RS, LS and GS, and can be produced quickly in practically any size up to a maximum length of 30 in.

We'll be pleased to furnish complete information about electroplated fasteners, whether you need a handful or a carload. Just get in touch with the nearest Bethlehem office, or write to us at Bethlehem, Pa.

BETHLEHEM STEEL COMPANY, BETHLEHEM, PA.

On the Pacific Coast Bethlehem products are sold by Bethlehem Pacific Coast Steel Corporation. *Export Distributor:* Bethlehem Steel Export Corporation



Bethlehem has complete facilities for volume production of electroplated fasteners. Inset shows the plating barrel in the coating solution.

BETHLEHEM STEEL

For more information, turn to Reader Service card, circle No. 479

TO ASSIST THE DESIGN ENGINEER IN THE PROPER SELECTION OF MATERIALS

We have coordinated a group of specialized laboratories for the purpose of assisting the Design Engineer in the selection of materials and augmenting his own research and development programs.

We are currently performing these services in the fields of ceramics, plastics and polymeric materials, chemicals, industrial textiles, industrial leathers, metals and alloys, paper, surface coatings, and wood.

Our program includes performance testing, materials testing, evaluation, development of specifications, development of new materials, studies of effects of impurities on material properties, evaluation of finishes, comparisons of alternative materials.

UNITED STATES TESTING COMPANY, INC.
ESTABLISHED 1880
1600 Park Avenue, Hoboken, N. J.
BOSTON · BROWNSVILLE
DALLAS · DENVER · LOS ANGELES
MEMPHIS · NEW YORK · PHILADELPHIA
PROVIDENCE · SAN ANGELO

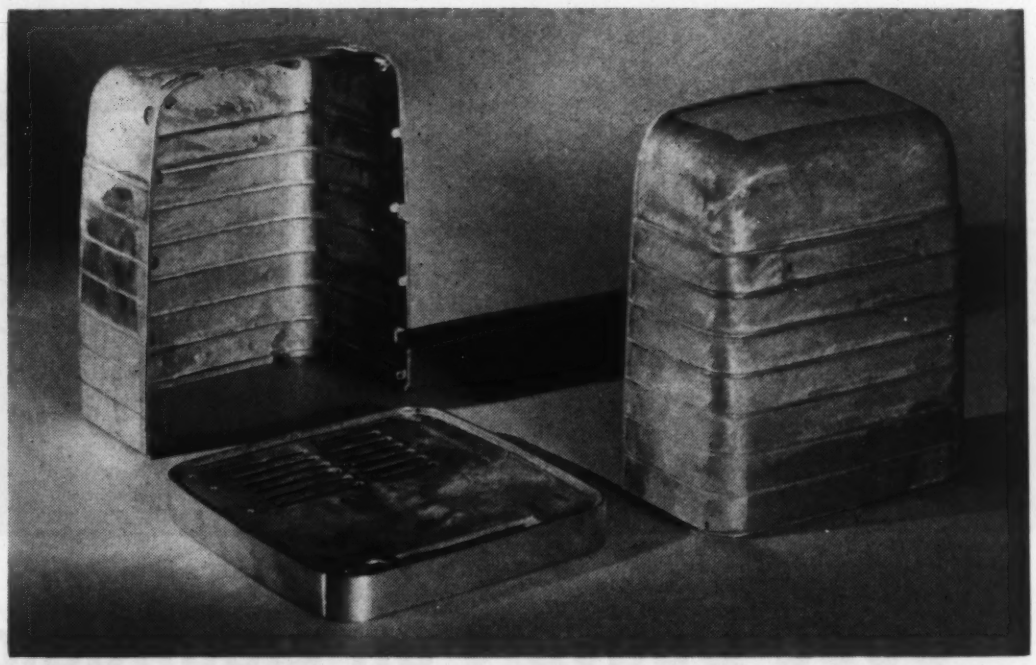
For more information, circle No. 510

MATERIALS AT WORK

Hangar sheath—cont'd from p 12

The aluminum sheets are received from the rolling mill 45 5/8 in. wide in a variety of lengths between 6½ to 12 ft. The sheets are 0.032 in. thick with 7/8-in. deep corrugations and weigh approximately 55 lb per 100 sq ft. They are laid from bottom to top of the hangar's 235-ft roof arc with the corrugations running vertically. Length of individual sheets used varies with the degree of curvature. The sheets are fastened to the deck with 2½-in. self-tapping chromium-nickel screws which are inserted in drilled holes at the crown of every third corrugation in rows running across the roof at 4-ft levels.

Die Cast Projector Housing



***Ready-to-use castings** are joined to form . . .*

■ Quality appearance, light weight, strength, ease of assembly and low cost are the reasons given for the selection of aluminum die castings for the housing of the Bell & Howell motion picture projector.

As shown in the photo above, three die castings make up the complete housing and base. The castings are ready for use as received from the foundry: all flash has been removed, and cored holes and recesses have been drilled or punched. The only subsequent operations necessary are preparing holes for self-tapping screws and applying a metallic baked enamel coating. According to Bell & Howell, "No other method of fabrication provides the durability and precision required for photographic equipment."

***. . . compact, attractive case** for movie projector.*

(more Materials at Work on p 202)

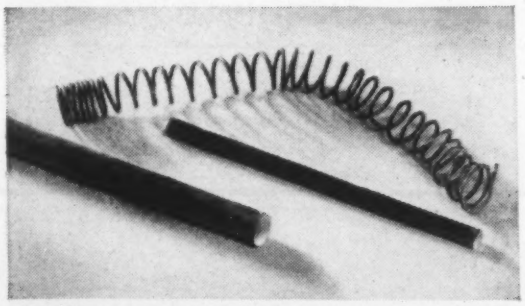
RARE EARTH RESEARCH

Recent interesting rare earth research developments

a report by LINDSAY

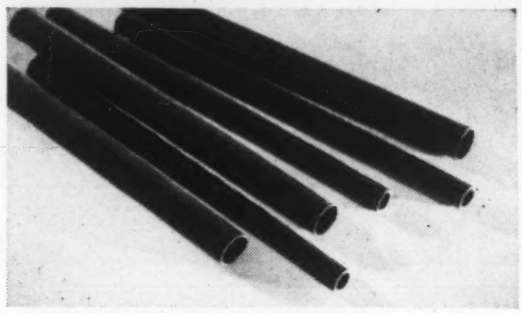
We are frequently fascinated by the imagination of researchers who are working with the rare earths. It appears that technical people, observing the many essential uses of rare earth salts in chemical and industrial processes, are looking at these fifteen unique elements as a fertile field for exploration.

During recent years, rare earths have been accepted as basic chemical tools in a wide cross section of American industry. This suggests that fruitful results may be expected from the rare earth research projects currently being carried on in industrial laboratories and pilot plant operations from coast to coast. Here, for instance, are half a dozen which may interest you.



MILES OF MISCH. This isn't a new application, but we're wondering if you know that misch metal (an alloy of the mixed rare earths) is available in wire form as well as in ingot and rod form? Cerium alloys can also be had in powder form; they are used as getters in vacuum tubes. We don't make the metal, but we can put you in touch with those who do.

FLAME SPRAYING. A new process for flame spraying various refractory oxides on metallic surfaces has been brought to near completion. Titania, zirconia and alumina can be flame sprayed, but the thing that interests us is that flame sprayed cerium oxide has some unusual properties. Rare earth oxide is a good heat radiation material, and it seems that metallic surfaces coated with rare earth oxide radiate heat much faster than do untreated surfaces.

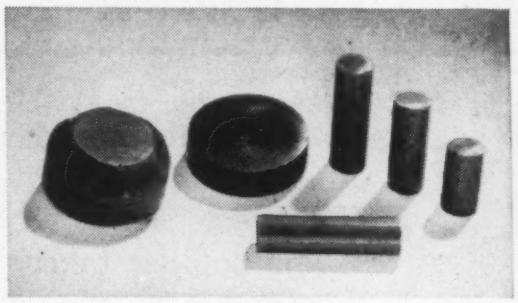


RARE EARTHS IN PLASTICS. We frankly don't know what sort of things rare earth-impregnated plastics could be used for, but a couple of people have taken enough interest in this problem to make up experimental samples. We've been doing some playing with them ourselves and have some ideas about using them. Polyethylene, for example, can be fabricated to hold up to 5 to 10 times its weight of rare earth oxide, and we've even seen some precision-bore epoxy tubing made with a rare earth oxide filler.

SEPARATION AND SAMARIUM. We are like a slaughter house in that we would like to use everything that a rare earth separation process turns out, including the squeal. With the interest that has been generated in using gadolinium as a neutron absorber (thermal cross section about 46,000 barns), we have accumulated quite a pile of samarium oxide in rather decent purity. In the process of separating gadolinium and some of the other rare earths, samarium is produced as a by-product. If you can think of a use for samarium, we have the samarium compounds.

RARE EARTH GARNETS. These are structurally somewhat similar to the garnet variety grossularite (formula $Ca_3Al_2(SiO_4)_3$). The most interesting ones are the rare earth-iron garnets such as $Y_3Fe_2(FeO_4)_3$. This mouthful of formula has been abbreviated by researchers to "YIG" for obvious reasons. Other names stem from other rare-earth symbols. These garnets, particularly those of yttrium, gadolinium, erbium, and some others have interesting ferromagnetic properties, making them useful as ferrite materials in electronic equipment. We don't make the garnets, but we do make the rare earth oxides needed to prepare them.

SINTERED SHAPES. One of our friends once wanted to know if rare earth oxides could be pressed and sintered into shaped pieces. Apparently they can, and our friend made up some experimental hot-pressed rare earth oxide and cerium oxide pieces for us.



Lindsay produces thorium and rare earth salts in purities up to 99.99% for a rather surprising variety of chemical and industrial applications. Most of these materials are available for prompt shipment in quantities from a gram to a carload.

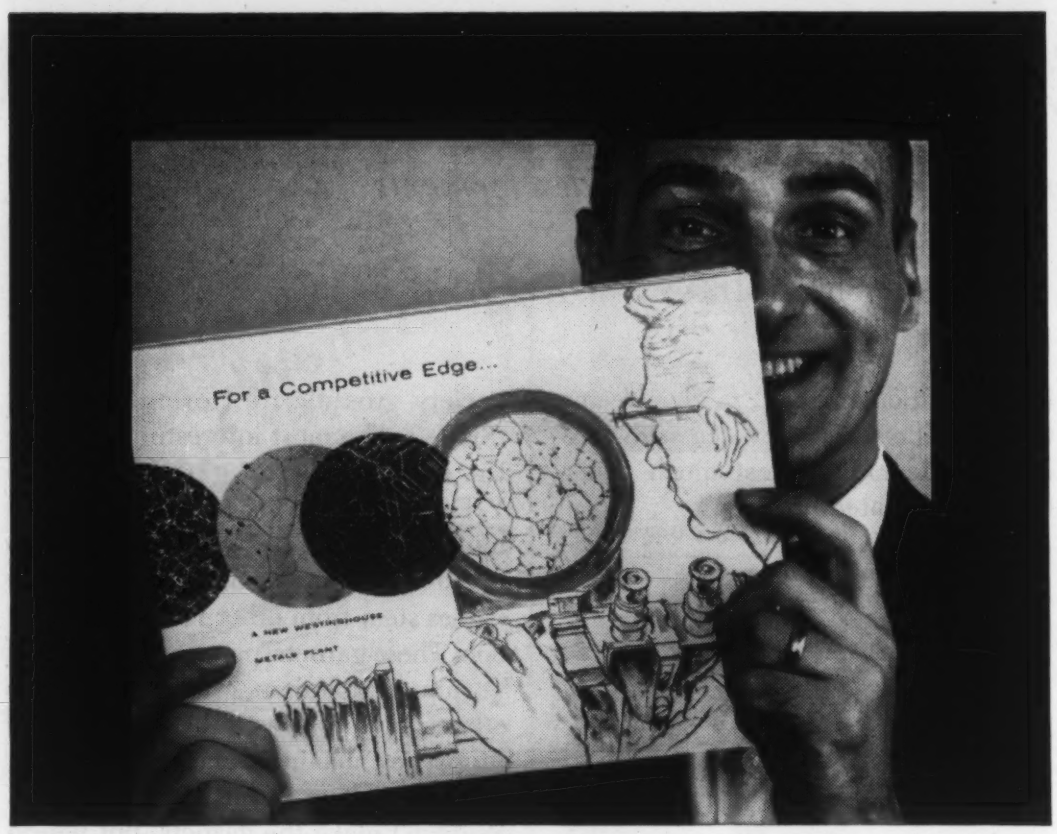
We will be pleased to supply your research and process development people with technical data, analyses, prices and whatever may be helpful to you in exploring the possibility of the profitable application of rare earths to your own problems.

PLEASE ADDRESS INQUIRIES TO:

LINDSAY CHEMICAL COMPANY

World's Largest Producer of Thorium and Rare Earth Chemicals

276 ANN STREET, WEST CHICAGO, ILLINOIS



ALLOYS AND CASTINGS FOR A COMPETITIVE EDGE

FREE . . . send for your copy of the helpful new Westinghouse booklet, *For a Competitive Edge* (B-6570). It describes how you can keep up with metals advances in the face of increasing investment and rapidly expanding metals science.

The booklet takes you on a tour of the new Westinghouse metals plant at Blairsville, Pa. Pilot plant facilities here can help you explore full production conditions and create prototype quantities for wrought alloys and molded-metal products. Some production capacity can be made available for fast, dependable delivery of metal products.

Arrange to see the 16-mm, full-color, 22-minute Westinghouse film, *This New World of Metals*. Write Westinghouse Electric Corporation, Materials Manufacturing Department, Blairsville, Pennsylvania. J-05003

YOU CAN BE SURE...IF IT'S

Westinghouse

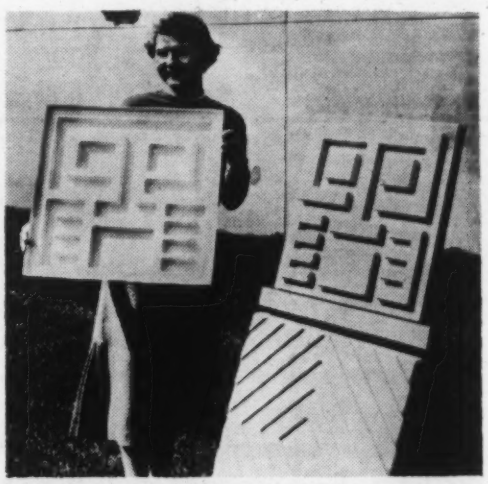
For more information, turn to Reader Service card, circle No. 586

MATERIALS AT WORK

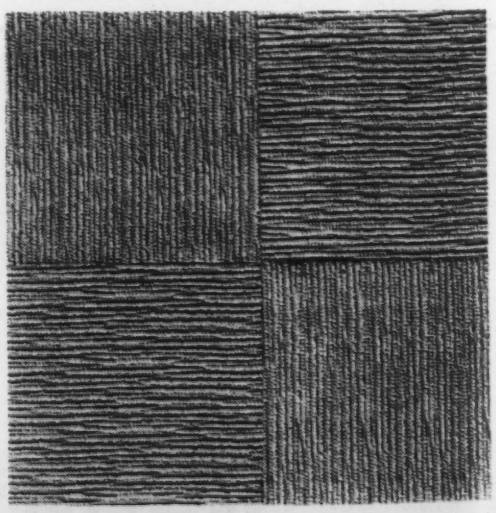
Rubber-Plastic Blend for Cement Form Liners

An inexpensive method of producing an almost limitless variety of textures and patterns on concrete surfaces uses form liners made of a rubber-modified styrene. According to the Portland Cement Assn., the liners can produce 1) sharp, crisp patterns with a smooth, almost glassy surface that requires no cleandown, grinding or finishing, or 2) rough, textured surfaces.

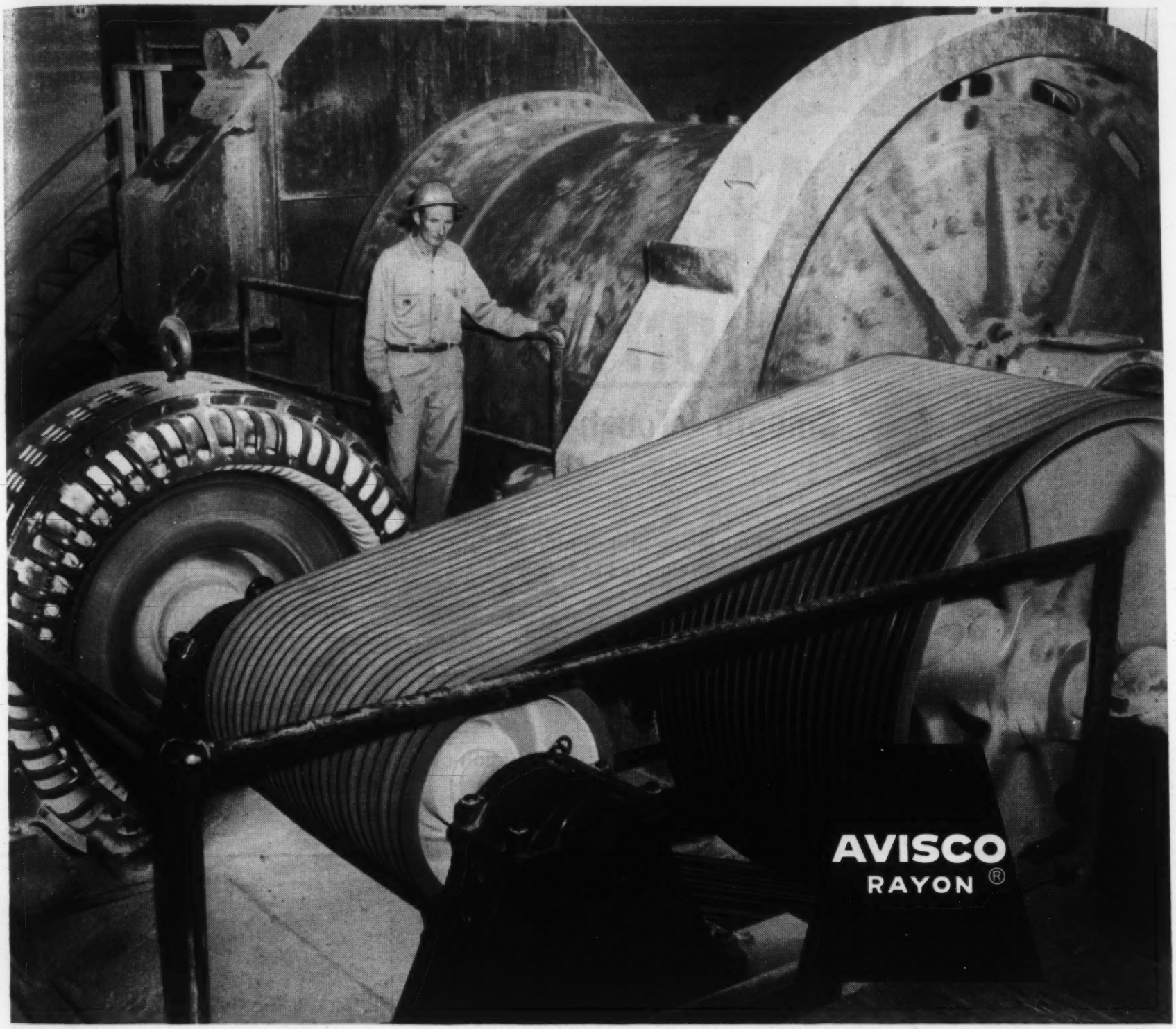
The liners, vacuum formed from U. S. Rubber Co.'s Royalite sheet, can be made to order in almost any pattern. No special concrete mix is necessary, and both lightweight and heavy aggregates are suitable. Best re-



Decorative patterns *are easily cast in concrete by using special rubber-plastic form liners.*



Textured surfaces, *especially suitable for ceilings, are also produced with the liners.*



Six years of continuous operation, without losing an hour. They're B. F. Goodrich Multi-V belts, with Avisco rayon as tough reinforcing "muscle," and they promise to last many more years. This performance since 1951, under conditions requiring greatest strength, flexibility and freedom from elongation, may suggest an application in your business. And remember, Avisco rayon gives greater strength per dollar than any other reinforcing material.

American Viscose Corporation

350 FIFTH AVENUE, NEW YORK 1, NEW YORK

For more information, turn to Reader Service card, circle No. 373

A New Material is Born!

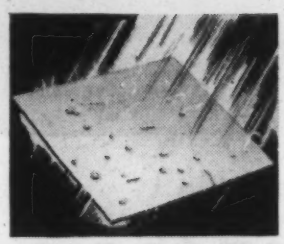
ALLFAB Orlon* Mat

Smooth • Tough • Durable

Low-cost surfacing and reinforcing fabric for the Plastics Industry

ALLFAB Orlon Mat comes from a special Felters' process which combines short fibers of Orlon with a thermoplastic resin binder — producing a uniform bonded fabric at low cost.

In reinforced plastics, the combination of properties is quite unusual . . .



- High abrasion resistance
- Resists temperatures to 300°F
- Excellent surface finishing characteristics
- Resists chemicals, weathering, staining, sunlight
- Excellent electrical insulating properties
- Low moisture absorption, no fiber wicking
- Can be easily deep drawn and fabricated
- Post-formable

ALLFAB Orlon Mat offers many new and intriguing possibilities . . . as an overlay or reinforcement. It greatly improves utility and appearance of standard glass reinforced laminates — adds to strength, surface smoothness and durability.

Send for details on the new ALLFAB Orlon Mat NOW. See how its many properties can help in styling, design and performance. Write or call today.

ALLFAB Orlon* Mat

A NEW MATERIAL FROM

THE FELTERS COMPANY

Manufacturers of Felt and Felt Products
220 South St., Boston 11, Mass.

*Registered trademark for duPont's acrylic fiber

FE 7-27

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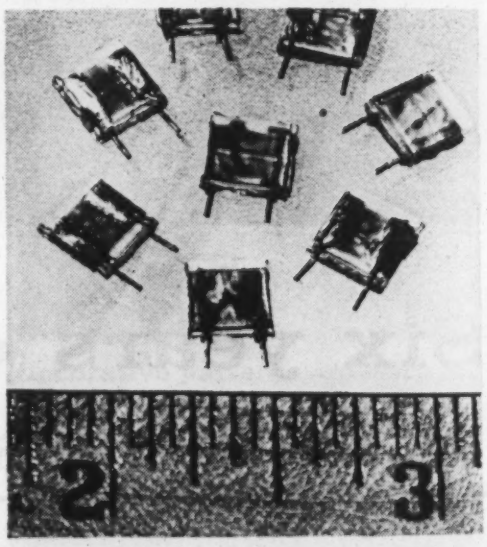
sults are obtained when the patterns are no deeper than ½ in., and edges and corners are rounded.

In addition to cutting finishing costs to almost nothing, the liners themselves are relatively inexpensive and can be re-used indefinitely.

Iron Powder Part Replaces Steel Bars

The switch from extruded steel bars to iron powder parts for the clutch lever used on Chrysler Corp.'s 1957 cars is a good illustration of how materials shortages can be overcome by utilizing different forms of materials.

When a shortage of extruded



Subminiature capacitors—Shown above are Corning Glass Works' new subminiature fixed glass capacitors. The capacitors, called Corning WL-4, measure 0.3 x 0.3 x 0.1 in. thick and are available in capacitances up to 1000 microfarads at 300-v rating. Main characteristics of the glass capacitors are: fixed temperature coefficient; high insulation resistance; low dielectric absorption; increased miniaturization; ability to operate under high humidity conditions; and the ability to withstand temperatures as high as 250 F for short time loads of low voltage applications.

Great advances in design . . .

NEED THE ADVANCEMENT IN WEAR RESISTANCE PROVIDED BY FLAME-PLATING BY LINDE

Lockheed's F-104A Starfighter, newest weapon of the Air Force, is the most advanced airplane of its type. To give them the greatest possible resistance to extreme conditions, bearing surfaces *(arrows)* of hot air valves used in the F-104A are Flame-Plated with tungsten carbide. Flame-Plating provides the wear-resistant coating needed to withstand the high unit loading and temperature extremes jet plane parts undergo.

Stratospheric altitudes . . . supersonic speeds . . . extreme temperatures subject jet plane parts to almost incredible conditions of heat and abrasion. To assure perfect operation in all circumstances, bearings of hot air valves in the Starfighter are Flame-Plated. A tungsten carbide coating, applied by LINDE's unique method, is the only material tried that successfully eliminated galling and provided a low coefficient of friction over the required service life of the part. With the part Flame-Plated, practically no wear occurred. This LINDE process is now a regular production procedure.

Flame-Plating is LINDE's special process for protecting metal parts from wear, abrasion, and fretting corrosion. Tiny particles of tungsten carbide or aluminum oxide are literally *blasted* onto the metal surface. Since the temperature of the part being coated seldom exceeds 400 degrees F., there is little or no risk of changes in its shape or metallurgical properties. Flame-Plated coatings can be applied from .002 to .010 inches thick, and used as coated or finished to 0.5 microinches rms. Practically all metals can be Flame-Plated—aluminum, magnesium, molybdenum, titanium as well as copper and steel.

Your own design may be improved by Flame-Plating. Find out how, by writing for a copy of the booklet "Flame-Plating," F8065. Address Flame-Plating, Dept. N-12, LINDE COMPANY, Division of Union Carbide Corporation, 30 East 42nd Street, New York 17, N. Y.
In Canada: Linde Company, Division of Union Carbide Canada Limited.

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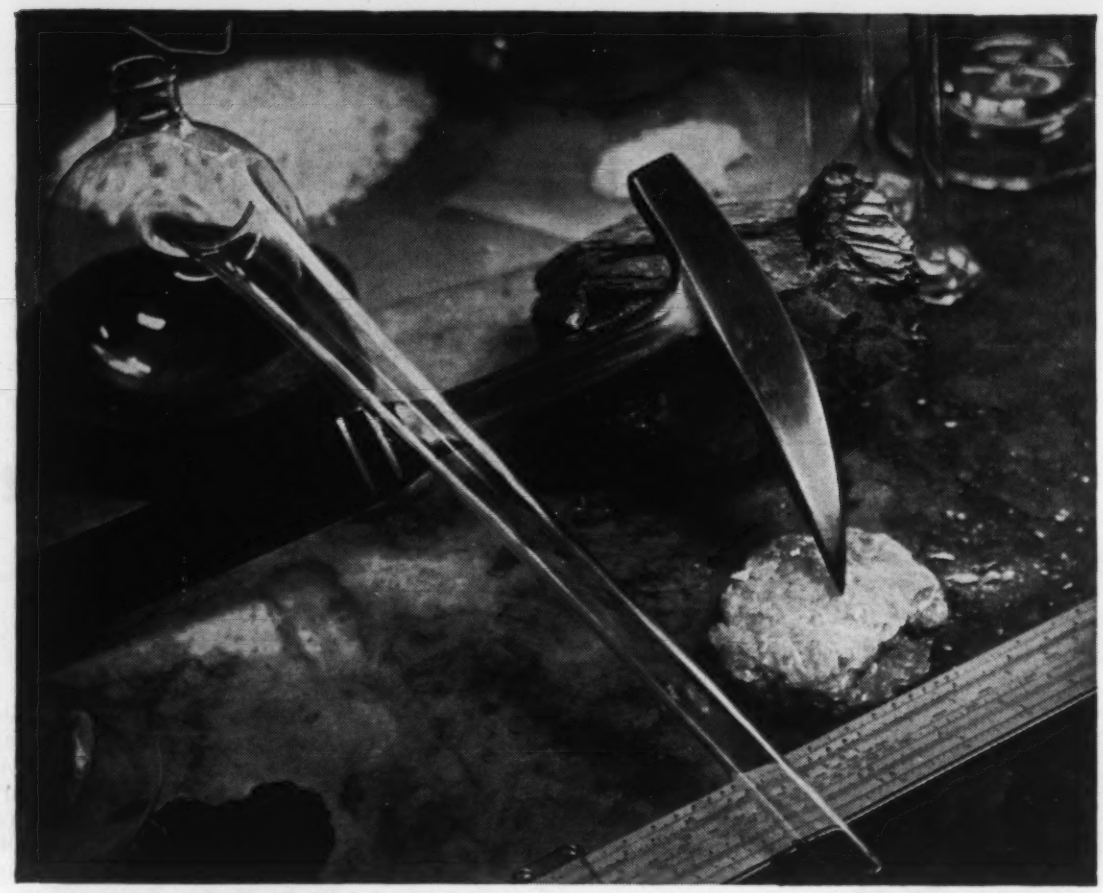
For more information, turn to Reader Service card, circle No. 412



THE HAMMER
AND THE RETORT

As the geologist's hammer signifies the mineral wealth locked in the earth's crust, the chemical retort signifies the power to free that wealth for the benefit of mankind. Together, the hammer and the retort symbolize the marriage of geology and chemistry that is the tradition and the future of the Foote Mineral Company.

Founded eighty years ago as a supplier of mineral products, Foote has expanded constantly, until now its business includes mining, mineral and alloy processing, chemicals, and metals. And the pioneering done by the company in the extraction and application of many lesser known elements has contributed substantially to many important technological advances.

Foote Mineral Co., 408 Eighteen West Chelten Building, Philadelphia 44, Pennsylvania.

Foote MINERAL COMPANY

RESEARCH LABORATORIES: *Berwyn, Pennsylvania*
PLANTS: *Cold River, N.H.; Exton, Pa.; Kings Mountain, N.C.; Knoxville, Tenn.; Sunbright, Va.*

LITHIUM CHEMICALS, MINERALS, METALS • STRONTIUM CHEMICALS • ELECTROLYTIC MANGANESE METAL • WELDING GRADE FERRO ALLOYS • STEEL ADDITIVES • COMMERCIAL MINERALS AND ORES • ZIRCONIUM, TITANIUM, HAFNIUM (IODIDE PROCESS)

For more information, turn to Reader Service card, circle No. 463

steel made it necessary to redesign the clutch lever that actuates the automatic transmission so that other forms of steel could be used, it was found that complex and costly machining would be required. The part had to be redesigned in 48 hr and had to be in production in three weeks. It was decided to try powder metallurgy. The resulting iron powder part, developed by Amplex Div., has since proved to be as effective as the steel bar.

Redesign Cost Avoided by Silicone Finish

Use of a heat resistant silicone finish has eliminated the necessity for redesigning a heater unit which was found to generate more heat than the original finish could withstand. According to Midland Industrial Finishes Co., the upper grille of the heater (see photo) often reachs a surface temperature of 550 F. The use of an organic finish would have required raising the grille—at a considerable redesign expense—in order to provide necessary protection for the lower part of the heater. Tests with the silicone finish, however, indicated that it would provide the required protection.

***Heat resistant** silicone finish protects heater from high temperatures generated at grille.*

Special Reports On Finishing Non-Ferrous Metals

NUMBER II—Paint Base, Corrosion-Resistant Finishing with Iridite

WHAT IS IRIDITE®?

Briefly, Iridite is the tradename for a specialized line of chromate conversion finishes. They are generally applied by dip, some by brush or spray, at or near room temperature, with automatic equipment or manual finishing facilities. During application, a chemical reaction occurs that produces a thin (.00002" max.) gel-like, complex chromate film of a non-porous nature on the surface of the metal. This film is an integral part of the metal itself, thus cannot flake, chip or peel. No special equipment, exhaust systems or specially trained personnel are required.

Chromate conversion coatings are well known and accepted throughout industry as an economical means of providing corrosion protection, a good paint base and decorative finishes for non-ferrous metals. However, continued developments have been so rapid and widespread that many manufacturers may not be completely aware of the breadth of application of this type of finish. Hence, this digest of current information, to bring you up to date on the many ways in which you can obtain proper surface preparation for painting and increase product durability with a single multi-purpose chemical pretreatment. Report I on decorative, corrosion-resistant finishes and Report III on chemically polished, corrosion-resistant finishes are available on request.

First, it is an accepted fact that metal surfaces should be prepared before painting to make possible an efficient paint system. Naturally, this preparation should provide for good initial paint adhesion. Chemical treatments have proved extremely effective in this respect, particularly those of a neutral or preferably acid nature. Further, to be most efficient, chemical treatments should provide a non-porous barrier to maintain adhesion by sealing the metal from the paint and moisture. They should also provide a self-healing film which prevents lateral corrosion in the event that bare metal is exposed through scratching.

The Iridite chromate conversion coatings meet all these requirements. Iridite is a chemical conversion treatment for surface preparation. It provides initial paint bonding by molecular adhesion. It is acid in nature and produces a film that is gel-like and non-porous in structure. Thus, the Iridite film effectively seals the metal from the paint and from moisture penetration. Because the film contains certain relatively soluble constituents, it will protect areas scratched through to bare metal and prevent lateral corrosion. This is accomplished by a gradual leaching of these constituents into the damaged area.

Further, because of its gel-like, non-crystalline nature, the Iridite film will not affect the appearance or texture of the paint film, nor will it dust or powder to mar the painted surface. Because the film is non-porous, paint coverage is increased, thus substantial savings in paint costs will be realized. In addition, treated parts may be stored for long periods of time prior to painting without the risk of entrapped moisture causing blistering when painting.

Iridite chromate conversion coatings are widely used with equal ease and success under both baked and air-dried paint systems. While the actual adherence properties of the Iridite film do not increase appreciably with its thickness, corrosion protection does. The protection of the Iridite film is proportionate to its thickness and should be taken into consideration when selecting the Iridite to meet your needs. However, it is sometimes necessary to sacrifice maximum corrosion protection for appearance when a finished part is to be only partially painted. For example, it may be desirable to use a thin, clear, bright Iridite film if the unpainted areas must present a chrome-like appearance. A typical case is that of instrument housings on which the exterior is painted and the inside left unpainted.

On the other hand, if all surfaces of the product are to be painted and maximum corrosion protection is required, the heavier and most protective Iridite films should be used. For example, all surfaces of zinc die cast fruit juices are finished with a highly protective Iridite film prior to painting to provide maximum resistance to the corrosive action of fruit juices.

Iridite finishes are now available for all commercial forms of the more commonly used non-ferrous metals, including zinc, cadmium, aluminum, magnesium, silver, copper, brass and bronze. In addition to providing an excellent base for paint, the Iridite films also have high decorative value when used as final finishes in themselves.

These films can produce a wide variety of pleasing appearances including clear bright, iridescent yellow, bronze, olive drab and brown. In addition, many films can be modified by bleaching or by dyeing. Among the dye colors available are various shades of red, yellow, green, blue or black.

In planning or designing, you should consider the many other characteristics of Iridite finishes which may enter into the specific problem. In addition to their functions as protective and decorative finishes, and as bases for organic finishes and bonding compounds, Iridites have low electrical resistance. Some can be soldered and welded. The film does not affect the dimensional stability of close tolerance parts.

Iridites are widely approved under both Armed Services and industrial specifications because of performance, low cost and savings of materials and equipment.

You can see then, that with the many factors to be considered, selection of the Iridite best suited to your product requires the services of a specialist. That's why Allied maintains a staff of competent Field Engineers—to help you select the Iridite to make your installation most efficient in improving the quality of your product. You'll find your Allied Field Engineer listed under "Plating Supplies" in your classified telephone book. Or, write direct and tell us your problem. Complete literature and data, as well as sample parts processing, is available. Allied Research Products, Inc., 4004-06 East Monument Street, Baltimore 5, Maryland.

(Adv.)

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NEWS and DATA

ON TECHNICAL PAPERS FOR

Filtering!

H-70...*for collection and monitoring of radioactive dusts and other airborne particles.* Made from specially selected vegetable and mineral fibers. Mechanical strength, surface fuzz, caliper and air resistance controlled to optimum degree. Furnished with water repellent (silicone) treatment. Can be supplied with gauze backing.

IMPORTANT CHARACTERISTICS

	Caliper .009"	Caliper .018"
Ream Weight (24 x 36/500)	45-50 lbs.	90-100 lbs.
Tensile Strength (Ave. Length)	2.5 lbs./inch	4.0 lbs./inch
Air Resistance* (Ave.)	175 mm water	200 mm water
Smoke Penetration* (Ave.)	Less than 2%	Less than 1%
Surface — Calendered and as free from fuzz as possible		

*Air resistance and smoke penetration are measured at 85 liters per minute through 100 sq. centimeters sample area. Samples are exposed to liquid type smoke of particle size approximately 0.12 micron radius as a total smoke concentration of 100-150 micrograms per liter.

Filter Crepe No. 15...*filtration of liquids in hydraulic systems.*

Combination of fibers provides special qualities suitable for filtration of most any kind of liquid. Has unusually low porosity: 1½% wet strength; 12 to 22 mm air resistance at 28 linear feet per minute; Tensile strength: 8; Stretch: 7%.

Vacuum Bag Filter Paper...*with high strength and open porosity.*

A 100% Manila fiber sheet which provides excellent dust retention along with low porosity and good strength. Special variations can be made as required for particular applications.

SEND FOR DATA SHEETS ON H&V TECHNICAL PAPERS

Over 31 different fibers can be combined to make a paper with special qualities and properties. Write today.

H&V

HOLLINGSWORTH & VOSE COMPANY

EAST WALPOLE, MASSACHUSETTS

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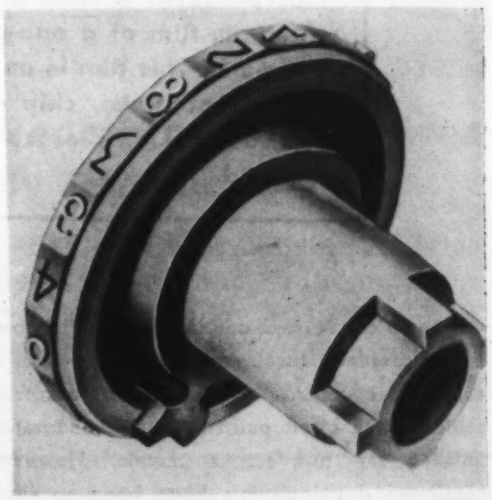
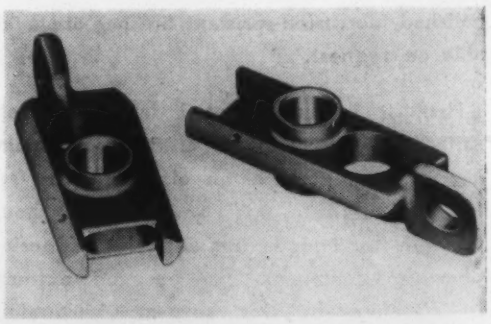
Investment Castings Are Cheap, Efficient

The advantages of investment casting are well known and these parts are finding more and more applications. In order to illustrate the benefits that can be derived from their use, the Investment Casting Institute has published several case studies, some of which are summarized here and on p 210.

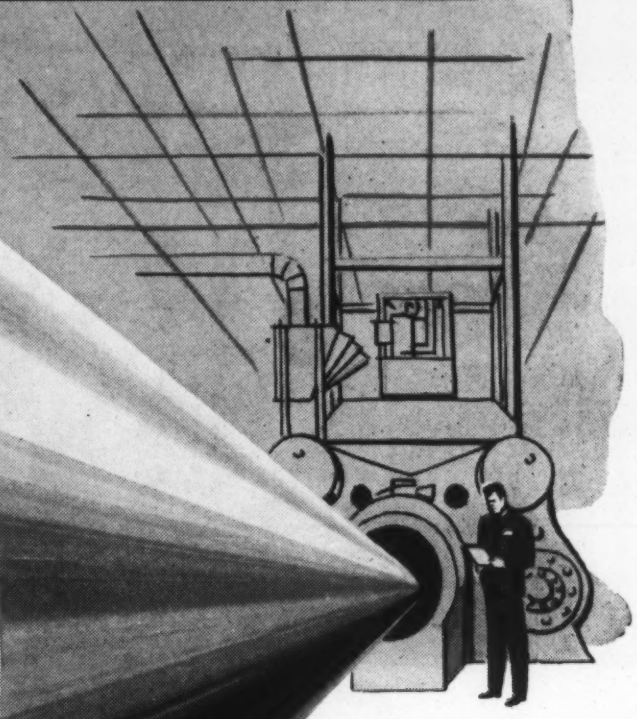


1. Numbering wheel—*The part shown here, investment cast in one piece from 4140 steel, was originally made by brazing together seven components: hub, sprocket, wheel, edge and center rings, advance cog and end clutch. As an investment casting, the part is priced at less than half the cost of the fabricated wheel.*



2. Cross head—*This cross head, used on a cloth cutting machine, was previously hogged from solid steel stock. In addition to requiring a large number of expensive milling operations, this method wasted more than 50% of the material as chip. By investment casting the part of SAE 1020 steel, subsequent operations needed are reduced to finish machining and grinding, plus case carburizing and hardening.*

FOR YEARS OF PIPE ECONOMY...



THIS EXTRUDED HEAVY WALL

PROTECTS

against severest heat, pressure and corrosion

Here is High Integrity pipe for the toughest applications in the power, petroleum, chemical and other industries. Extruded from any ferrous alloy in lengths up to 50 feet or more, and with virtually any wall thickness, this pipe from the Curtiss-Wright Metals Processing Division provides increased on-the-job life, long-term economy, elimination of down time – not just for months, but for years to come. Extruded to specification under tremendous one-push pressures from the Division's giant 12,000-ton horizontal steel extrusion press, Curtiss-Wright Heavy Wall Pipe is of uniform high strength and has high resistance to pressure, heat and corrosion. Write today for information on both your standard and special requirements.

76 GRIDER STREET

METALS PROCESSING DIVISION
CURTISS-WRIGHT
CORPORATION • BUFFALO, N. Y.

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Another Tinius Olsen First

a
S·P·L·I·T
CABINET
ElecΦmatic
UTM

A flexure test on a glass bar is being made with a Split Cabinet 60,000 lb. ElecΦmatic U.T.M. at Corning Glass Works,

Now you can enjoy all of the testing convenience and accuracy of the Olsen ElecΦmatic, plus the advantages of split cabinet design—including no shock transfer . . . maximum floor space utilization . . . ability to locate loading and indicating units in separate areas for remote control testing of explosive or radioactive materials, etc. The only connection between the two cabinets is electrical wiring.

In addition, only the Olsen ElecΦmatic gives you a minimum of 100:1 ratio of test ranges . . . four range capacities . . . positive testing speeds under load as well as no load . . . plus the availability of Olsen Electronic Recorders and the widest selection of strain instrumentation available. The low inertia of the Olsen weighing system coupled with fast-acting servos enable the indicating system to follow and indicate the load accurately regardless of the testing speed. Response time for both stress and strain is only 4 seconds for full scale range.

Get the facts about Olsen ElecΦmatic testing machines —now available in split cabinet or single cabinet design. Write today for Bulletin 54.

Trademark
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TINIUS OLSEN
TESTING MACHINE COMPANY
2010 EASTON ROAD • WILLOW GROVE, PA.

Testing and Balancing Machines

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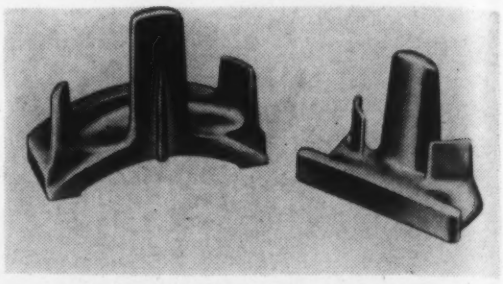
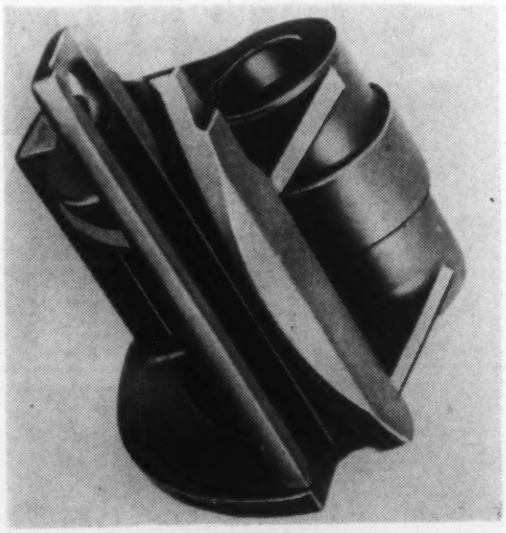
MATERIALS AT WORK



3. Coil winding forms—*The parts shown here were formerly machined from solid steel stock at costs from $5 to $35 each. The same parts are now being investment cast at a cost of $3.50 each in lots of 50 pieces. Except for a minor polishing operation, the parts are used as cast.*



4. Shuttle lifter—*This weaving machine shuttle lifter was originally fabricated from nine parts. The parts included a sand casting machined to size, a stamping, three machined parts, two machine screws and two lock washers. These parts were screwed and welded together. As investment cast in one piece, the part now weighs only 10 oz and is said to have reduced costs by as much as 86%.*

Aluminized Asbestos Keeps Driver Cool

Latest application of Keasby & Mattison Co.'s aluminized asbestos cloth is shown in the accompanying photograph where it is being used as a protective, heat resistant cover for a catalytic exhaust purifier installed on the counterweight of a fork lift truck.

The catalytic purifier is used to

Sigma Welding
gets truck trailers on the road fast

High-speed production of aluminum truck trailers calls for fast and efficient methods of welding. LINDE's Sigma Equipment and LINDE Argon keep trailer production lines rolling.

LINDE Apparatus for Sigma welding makes top-quality joints in all commercial metals. Production speeds up to 100 inches per minute are easily obtained, with clean, smooth welds. LINDE Argon, guaranteed 99.99% pure, is used to shield the arc. It's readily available in cylinders or in bulk, from convenient sources all over the nation.

Find out how LINDE Sigma Apparatus and LINDE Argon can help improve your product and increase your production. For a free copy of the booklet, "Modern Methods of Joining Metals," address Dept. N-12. LINDE COMPANY, Division of Union Carbide Corporation, 30 East 42nd Street, New York 17, N. Y. *In Canada*: Linde Company, Division of Union Carbide Canada Limited.

Sigma welding, with LINDE Apparatus and LINDE Argon, makes possible high-speed production welding of aluminum and other commercial metals, manually or automatically.

FOR THE BEST IN ELECTRIC WELDING—LOOK TO LINDE!

Linde
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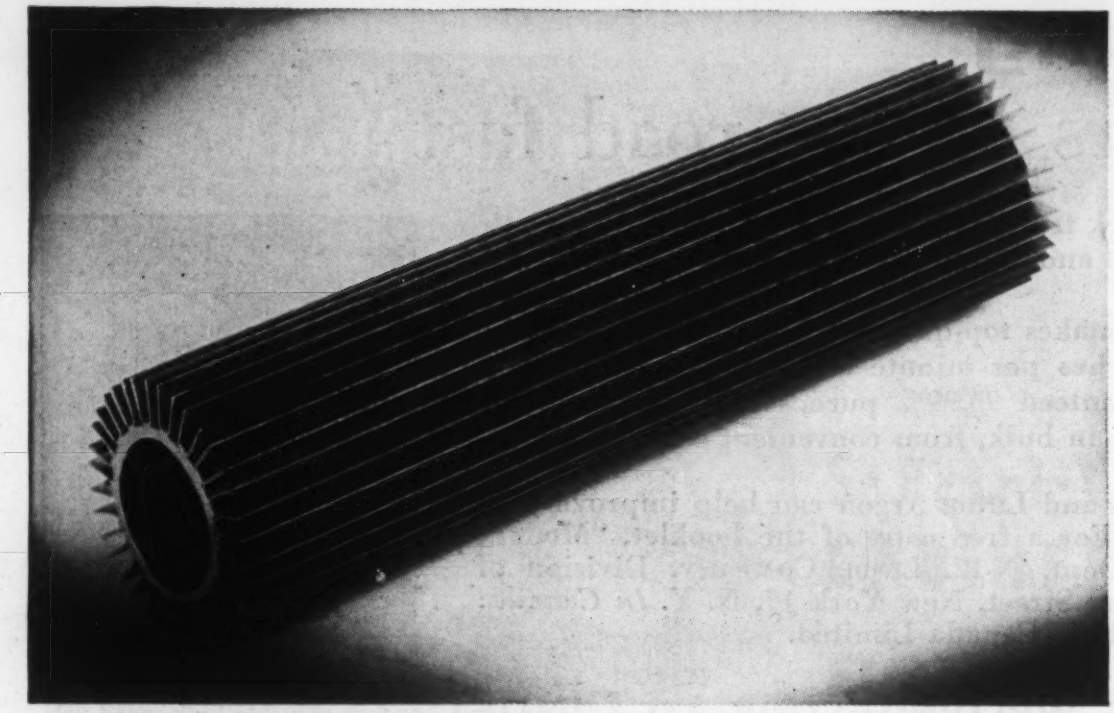
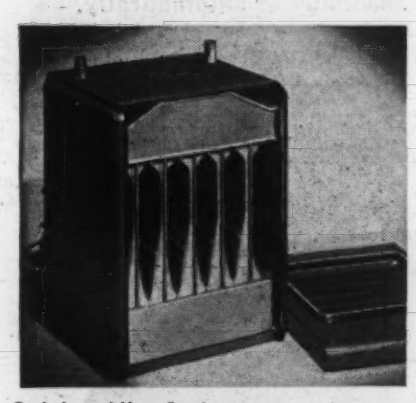
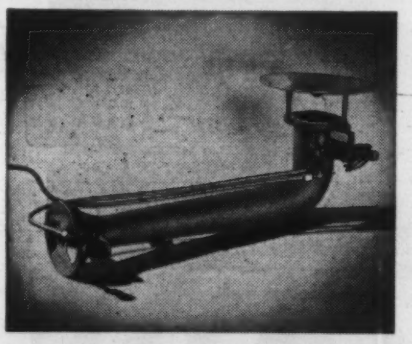


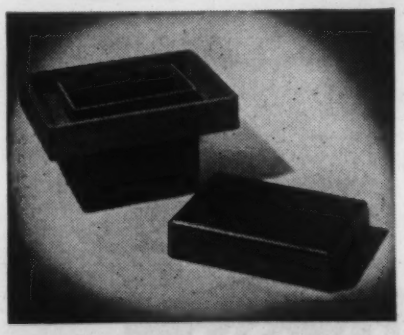
Heat exchanger used in evaporators and condensers will withstand 1600° F indefinitely.



Stainless Alloy Surface protects heat exchanger element in gas-fired unit heater which operates at approximately 1600° F.



Stainless Alloy Surfaced flame spreader replaces Stainless Steel spreader normally used in fuel burner nozzle at a 40% cost saving.



Heat treatment retorts operating up to 2600° F can be protected against heavy oxidation which reduces service life.

Heat Protection

Up to 2600° F.

Steels having a carbon content from 1008 to 1053 can now be given a *Stainless Alloy Surface* providing heat resistance equal to that afforded by Stainless Steels. A new, low-cost process — ASC Metal Diffusion — creates by atom interchange a chromium-rich surface that gives unlimited heat protection at 1600° F. and limited protection up to 2600° F.

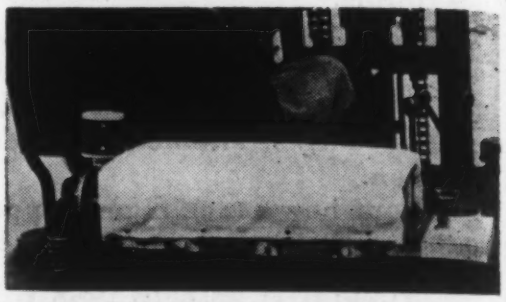
Unlike coatings, platings and claddings, an ASC Stainless Alloy Surface becomes an integral part of the processed work. It will not chip, peel, craze or crack. The Process is applicable to all iron, steel, and ferrous alloys — and forming, welding, brazing and soldering, can be done by methods in general use.

ASC Metal Diffusion also gives low and medium carbon ferrous products *corrosion* resistance equal to that of 430 stainless. Medium and high carbon content products can be given *wear* resistance surface hardness of RC 70-72. For more information about this revolutionary process write for data, consultation, or product demonstration.

ALLOY SURFACES COMPANY

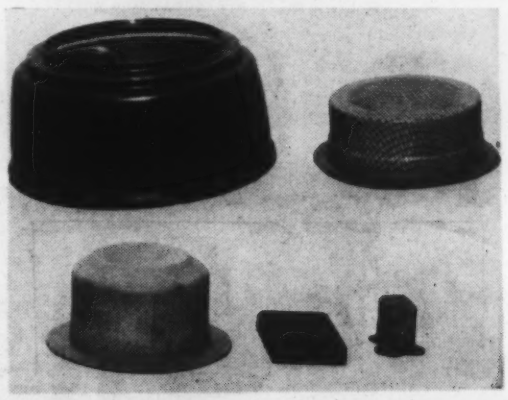
103 South Justison St., Wilmington 1, Del.

MATERIALS AT WORK



***Aluminum-surfaced asbestos** cloth protects driver from heat.*

eliminate as much as 90% of the carbon monoxide and other fumes in gasoline exhaust. However, the unit generates considerable heat. The aluminized asbestos cloth covering—a tightly woven asbestos cloth surfaced by a special process with a heat-protective aluminum foil—protects the driver from the heat because the smooth aluminum surface reflects over 90% of all radiant heat.



Hydroformed clad parts — The parts shown in the photo above are 0.040-in. thick plastics coated aluminum and 0.032-in. thick plastics coated cold rolled steel. They were all produced by the hydroforming technique. According to Hydroforming Co. of America, the technique offers the following advantages: any ductile metal or plastic can be deep drawn using only the male part of a die and draw rings to match; fine finishes are maintained; blanks can be painted or laminated before drawing, thus eliminating secondary operations; tooling costs are cut by as much as 90%; and materials anywhere from 0.005 to ⅝ in. thick can be deep drawn.

This spindle turns at 10,000 RPM without a jitter—that's the benefit of Welded Carbon Steel Tubing's "on-center" uniformity of roundness, wall thickness and concentricity.

Corrosion Resistant Welded Stainless Steel Tubing withstands constant contact with chemical dyes, pressure and wear in this packaging yarn dyeing equipment.

For 10,000 RPM's or fighting corrosion

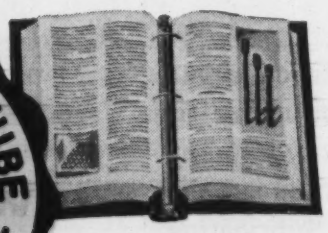
CHOOSE WELDED STEEL TUBING

Carbon • Alloy • Stainless Steel

Welded Tubing replaces solid sections for most high RPM applications because of direct savings and better results. Welded Tubing's broad and uniform characteristics help to solve problems ranging from high strength-to-weight ratios through pressure, temperature and corrosive applications. Only Welded Tubing has these advantages. For all tubing applications, consult a quality tubing producer.

An Association of Quality Tube Producers

FORMED STEEL TUBE INSTITUTE



Design inspiration for you

The 260-page Handbook of Welded Steel Tubing contains inspiration and data for tubing designs. For your copy, write on your company letterhead, giving your title.

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850 HANNA BUILDING • CLEVELAND, OHIO

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Weirkote's continuous-process zinc coating *thrives* on toughest fabrication steps—spinning, deep drawing, roll forming, extrusion. And there's no flaking or peeling.

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Send for the new booklet on Weirkote today. Write Weirton Steel Company, Dept. ***E-6,*** *Weirton, West Virginia.*

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NATIONAL STEEL CORPORATION

For more information, turn to Reader Service card, circle No. 382

PRICES AND SUPPLY

The Outlook by Herman B. Director, *Consultant, Washington, D. C.*

No increase in copper consumption

Although production of 1958 autos and appliances is now in full swing, there has been no rush on the part of fabricators to stock up on copper supplies. The slightly increased demand generated by the automotive industry has, in fact, done little more than bolster the custom smelter price at 25¼¢ per lb. And although there are indications that copper raw materials are not too readily available for spot deliveries, we feel that there is no possibility of a shortage. Inventories at refineries are still at an exceptionally high level, despite substantial production cuts which now amount to about 11,000 tons per month. And the chances are that there will be no further production cuts.

Lead and zinc use up slightly; imports way up

As a result of increased lead storage battery usage, there has been an increase in lead consumption. However, this increase has not created any pressure on supplies and is not likely to. Reason is that in anticipation of action by the Tariff Commission to

Director on Government Stockpiling

The Office of Defense Mobilization in Washington has appointed a Citizens' Committee to review the Government's stockpiling policy. However, there seems to be some confusion concerning the actual function of the Committee. One announcement indicated that the Committee would concern itself with stockpile policy; another stated that the Committee would concern itself with a review of each individual material in the stockpile. At any rate, there is at least going to be a review of our stockpiling activities.

One of the most difficult problems facing the Committee is that of materials disposal. Current materials inventories in our stockpile already exceed $6½ billion, with about $5 billion still to come. In addition to the strategic stockpile, the Government has a stockpile of materials acquired under the Defense Production Act as a part of the Government's Korean wartime program for increasing supplies of industrial materials. It had been hoped that these materials would be purchased by industry; however, supplies have so far outrun demand that the Government is now forced to buy about $138 million worth of aluminum, copper, nickel, tungsten, zinc, lead and many other materials.

Another serious problem facing the Administration is the existing legal limit on the Government's authority to borrow money. The unexpected increase in the amount of money that the Government has to spend for materials is complicating the Government's fiscal problems, and the Administration may be considering the possibility of reducing its financial commitments by either renegotiation of contracts or by disposal of Government-held surpluses. Some of these surpluses can be disposed of without additional authority.

Materials in the strategic stockpile and in the supplemental stockpile which were acquired through the barter of agricultural commodities for metals cannot be readily disposed of without Congressional approval. It may be, however, that Government lawyers can find some loopholes which would permit disposal of some of its materials stockpiles. The other alternative is for the Administration to ask Congress for permission to exceed the current debt limit and borrow more money for increased defense expenditures.

The Outlook—continued

increase the duties on lead and zinc, foreign producers have increased their shipments into the United States. For the first eight months of 1957, imports of zinc into the United States are reported to be 16% above that of last year. Lead imports in the first eight months of 1957 were 13% above the 1956 figures.

The Government apparently intends to continue its purchases of lead and zinc from domestic producers in an effort to support the price until such time as the Tariff Commisson makes its recommendations to the Administration and the Administration acts to increase the duty. As we have stated several times and now reiterate, imposition of the duty is likely to be absorbed by foreign producers who will continue to ship large quantities of lead into the United States. Therefore, as soon as the duty is imposed, and it seems to be a foregone conclusion that it will be imposed, zinc and lead producers are expected to make a pitch for import quotas. These import quotas would be designed to limit foreign producers in their shipments of lead and zinc into the United States. They will undoubtedly point out that, as in the case of agricultural commodities and many manufactured products, imposition of a duty does not result in decreased shipments of competitive materials or products into the United States.

Aluminum expansion slows down

Aluminium Co. of Canada has announced that it expects to slow down its expansion. The original plans called for an increase of about 100,000 tons by the end of 1958. However, company officials indicate that they expect supply to exceed demand for the next year.

U. S. producers, on the other hand, are more optimistic about consumption of aluminum and are forecasting a 15 to 20% increase in aluminum use in automobiles for the 1958 models. It is estimated that the automotive industry used 123,000 tons of aluminum in 1957. This is expected to increase to 200,000 tons in 1958. These estimates appear to us to be rather optimistic.

Mercury prices continue to decrease

As we had predicted last month, the price of mercury has decreased and is now quoted at $230 per flask. This is only $5 per flask higher than the Government support price, and if consumption remains as low as it is, chances are pretty good that most domestic production will head for Government stocks rather than to industry.

Steel consumption not up to expectations

The expected increase in steel consumption during the fourth quarter has failed to materialize, and it appears that inventories in consumers' stocks were grossly underestimated. The fact is that virtually all steel products are readily available on short order. Even heavy steels, which were previously hard to get, are now easily obtainable.

Copper Situation Alters; Prices Seen on Way Up

■ It seems that the price of copper has just about reached the low point and should start to rise within the next few months. At first glance this may appear to be a far-fetched prediction — especially considering the fact that more has been said about the "over supply" of copper during the last year than about any other metal. However, some interesting statistics, presented by Roy H. Glover, chairman of the board of Anaconda Co., seem to point to a definite reversal of this situation.

Speaking at the ceremonies dedicating a new copper mine in Chile, Mr. Glover pointed out that although there was a perfectly logical reason for the abundant supply of copper during the past year, there is an even more logical reason why this situation should end in the near future. He explained that statistics gathered over the last 40 years indicate that the amount of copper used in any year averages a little more than about 1⅓ lb of copper for 100 lb of steel. This ratio has increased slightly during time of war, but has never decreased below this level. From 1919 to 1940, the ratio averaged 1.383% of copper to steel. During the last war, it was 1.868%. From 1946 to 1956 it was 1.412%; and during the first half of 1956 the average was 1.315%.

What happened

During the first half of 1956, according to Mr. Glover, the copper industry, especially in the United States and Chile, "had been plagued with labor unrest and strikes." As a result, anyone who depended upon a steady source of copper ". . . felt compelled to maintain reserves of otherwise unneeded copper." In August 1956, however, the labor unions and the entire copper industry in the United States signed

(continued on p 226)

Here is an interim report on . . .

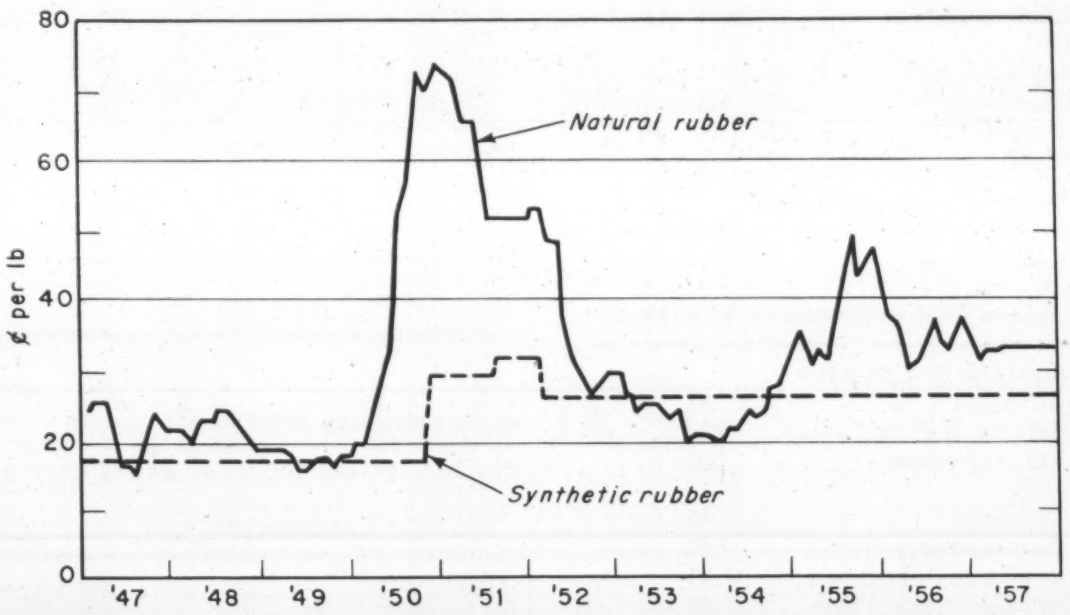
1957 Nonmetallic Production, Consumption, Prices

■ The trend seems to be in the direction of increased production of nonmetallic materials in practically all areas. This is especially true of plastics which for the first time will exceed 4 billion pounds in a year. And although only half-year figures are available, rubber consumption seems to be higher in 1957 than it was in 1956.

U.S. PRODUCTION OF KEY NONMETALLIC MATERIALS
(BILLIONS OF POUNDS)

Material →	Plastics	Synthetic Fibers	Rubber	
			Natural	Synthetic
1954	2.8	1.4	1.1	1.3
1955	3.75	1.7	1.4	2.2
1956	3.9	1.65	1.2	2.3
1957[a]	4.3	1.75	—	—

[a]Estimated.
Source: U.S. Tariff Commission, U.S. Dept. of Commerce, and Textile Economics Bureau.



Prices of natural and synthetic rubber from 1947 to 1957.

Plastics

The Society of the Plastics Industry sets 1957 plastics production at 4.3 billion pounds. This is considerably higher than the 3.9-billion-pound mark set last year. And continued increases are on the way. Polyethylene production, for example, is increasing at a phenomenal rate; by 1961 this material is expected to be the first "billion-pound" plastic (see MATERIALS IN DESIGN ENGINEERING, Nov '57, p 250). For 1957, however, vinyl and vinyl copolymer resins are expected to lead in production, with polystyrene and polyethylene following.

Plastics prices during 1957 tended, in general, to decrease. Prices were reduced on polystyrene, nylon, certain fluorocarbons and polyesters. Prices were increased on phenolics and high density polyethylene.

Synthetic fibers

Although rayon and acetate fiber production during the first half of 1957 was below production in the similar period of 1956, total fiber production this year is expected to exceed the record set in 1955. The reason: sizable increases for textile glass fibers and noncellulosic fibers. Production of noncellulosic fibers during the first half of 1957 was about 35% higher than in the first half of 1956; by the end of the year it is expected to jump from the 400 million pounds produced last year to just under 500 million pounds. Textile glass fiber production should increase from about 99 million pounds in 1956 to 110 million pounds.

By the end of the year, acetate production should equal that of 1956 and total rayon production should end up about 1 or 2% higher than it was in 1956.

Rubber

Domestic production of natural rubber amounted to about 1.2 billion pounds in 1956, and consumption was 1.1 billion pounds. Production of synthetic rubber in 1956 amounted to about 2.3 billion pounds, and consumption was 2.2 billion pounds. Figures closely approximating these are expected for 1957.

Price of natural rubber was about 33¢ per lb and synthetic rubber about 23¢ per lb during 1957. Although supply and demand for all rubber is fairly well balanced, use of the synthetic material is continually increasing percentage-wise. As a result, two schools of thought have risen concerning rubber prices during 1958: 1) continued improvements in synthetic rubber will necessitate a reduction in the price of natural rubber of as much as 20% in order for it to keep present markets; 2) on the other hand, so long as the ratio of production to consumption remains as it is, there will probably be no reduction in prices.

Year-End Reports

This is the second half of a preliminary report covering 1957 statistics on key engineering materials. Last month's article covered metals.

Prices of Materials

Changes since last month are bold-faced

NONMETALLICS

Prices for large quantities for range of grades, color, sizes; given in $/lb

RUBBER

Material	Dry	Latex
Butadiene-Acrylonitrile	.49-.65	.46-.54
Butadiene-Styrene	.17-.30	.22-.32
Butyl	.23-.28	—
Neoprene[a]	.39-.75	.37-.47
Silicone[a]	1.90-4	—
Polysulfide[a]	.47-1	.70-.92
Natural	.33[b]	—

[a]Less than carload quantities.
[b]Average spot price for month of Oct.

GLASS FOR REINFORCED PLASTICS

Fabric ($/yd 38 in. wide)[a]	
112 Woven	.48
181 Long-shaft satin weave	1.03
143 Unidirectional	1.00
Roving[a]	
Continuous	.40
Continuous spun strand	.36
Continuous chopped spun	.38
Milled fibers (1/32-¼ in.)[a]	.45
Mat	
Chopped strand (2 in.)[a,b]	.52-.72
Surfacing ($/1000 sq ft)[c]	10-19
Continuous chopped strand (¼-2 in.)	.40

[a]Price includes binder or finish.
[b]Price varies with binder.
[c]0.010-0.020 in. thick.

THERMOSETTING PLASTICS

Material	Molding Compounds	Laminating, Casting Resins
Alkyd	.34-.53	—
Epoxy	—	.45-.80
Melamine	.42-.45	.40-.41
Phenolic	.21-.40	.17-.34
Polyester	.42	.32-.50
Silicone	2.75-5.40	1.55-1.74[a]
Urea	.19-.33	—

[a]60% solids content.

All prices are approximate and given solely for general guidance of those responsible for materials selection.

THERMOPLASTICS

Material	Molding Compounds	Sheet (.030-.250 in.)	Rod		Tube	
			⅛-¼ in.	⅜-1¼ in.	⅛-¼ in.	⅜-1¼ in.
Acrylic	.51-.59	.49-2.15	.90-1.15	80-.90	1-1.15	.90-1
Cellulosic						
Acetate	.36-.65	.92-1.16	.75-1	.65-.75	.85-1	.75-.85
Butyrate	.50-.72	1-1.28	.95-1.20	.85-.95	1.05-1.20	.85-1.05
Nitrate	—	1.60-2.73	1.45-1.75		2.25-5.00	
Propionate	.51-.63	—	—		—	
Fluorocarbon						
CFE	7-8	15-23	18-22	14-20	20-22.50	16-20
TFE	4.50-7.45	14.30-11	13	13	13	13
Nylon	1.18-2.30	—	3	3	3	3
Polyethylene	.35-.56	.85-1	.75-1	.65-.75	.85-1	.75-.85
Polystyrene	.26-.44	.57-.61	.65-.90	.55-.65	.75-.90	.65-.75
Vinyl	.27-.43	.62-.92	.75-1	.65-.75	.85-1	.75-.85

NONFERROUS METALS

Mill base prices for large quantities; given in $/lb except where indicated

ALUMINUM

Pig (99-99.9%)	.26-.28
Ingot (99-99.9%)	.28-.30
Foil (5-0.5 mil)	.55-.77
Alloy Ingot (13, 43, A132, 214)	.29-.32
Sheet (1100, 3003; 3-0.03 in.)[a]	.43-.47
Plate (1100, 3003, 5050, 3004, 5052)[a]	.40-.43

[a]Mill finish.

BRASS

Form	Cart., 70%	Low, 80%	Red, 85%
Sheet, Strip	.43	.46	.46
Seamless Tubing	.46	.48	.49
Rod (not f.c.)	.44	.45	.46
Wire	.44	.46	.47

COPPER

Ingot (elec)	.25
Sheet, Strip (hot rolled)	.49
Seamless Tubing	.49
Rod, Drawn	.47
Rod, Free Cutting	.57
Wire	
Round	.32
Square, Rectangular	.35
Magnet	.40

LEAD

Common Grade	.14

MAGNESIUM

Pig (98.8%)	.35
Ingot (98.8%)	.36
AZ91B Ingot (die casting)	.37
AZ91C Ingot (sand casting)	.41[a]

[a]Delivered price.

NICKEL

Form	"F"	"A"	Monel
Ingot	.75[a]	—	—
Rod	—	1.07	.89
Sheet, C.R.	—	1.26	1.06
Strip, C.R.	—	1.24	1.08
Seamless Tube	—	1.57	1.29

[a]Delivered price.

TIN

Primary[a]	.93-.94

[a]Delivered price.

(continued on p 220)

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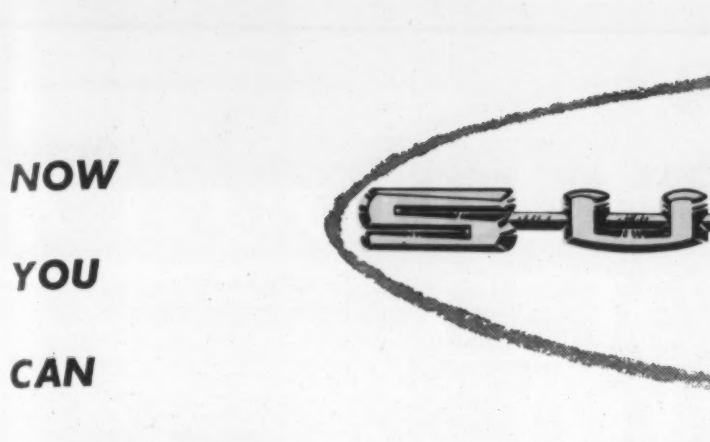
INTEGRAL LUG



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Colored or chrome-like anodized aluminum script, instead of plated or painted castings, are now available through our exclusive process. They will not pit—nor peel—nor chip—nor blister.

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The lugs can be any size or shape. They can be turned over or staked. They cannot break off. The lug is Kolforged from the plate—making lug and plate one integral unit.

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X-2358

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PRICES AND SUPPLY

TITANIUM

Sponge (99.3+%)	2.00-2.50
Bars, Rod	6.15-6.40
Plate	8.00-10.75
Sheet, Strip	6.50-11.10
Wire	7.50-8.00

ZINC

Prime Western	.10½ [b]
Die Casting Alloys [a]	.15-.16
Sheet	.24
Ribbon	.21
Plates	.19

[a]Alloys 2, 3, 5. [b]Delivered price.

METAL POWDERS

Aluminum [a,b]	.40
Brass [a]	.32-.40
Copper (elec or red.) [a]	.39
Molybdenum (98%)	3.80-4.10
Nickel	1.05
Tantalum	49
Tungsten (C-red. 98.8%; H_2-red. 99+%)	4-5 [c]
Zirconium	
Flash Grade	11.50
Electronics Grade	15

[a]Price for —100 mesh. [b]Freight allowed. [c]Delivered price.

OTHER NONFERROUS METALS

Cadmium (bars)	1.70
Columbium	55-80
Gold	$35/troy oz
Indium (99.97+%)	$2.25/troy oz
Manganese (99.9%)	.34 [a]
Palladium	$23-24/troy oz
Platinum	$84-87/troy oz
Silver	91¢/troy oz
Tantalum (sheet, rod)	55-60
Vanadium	80
Zirconium (sheet, strip, bar)	27-35

Delivered price.

IRONS AND STEELS

Mill base prices for large quantities

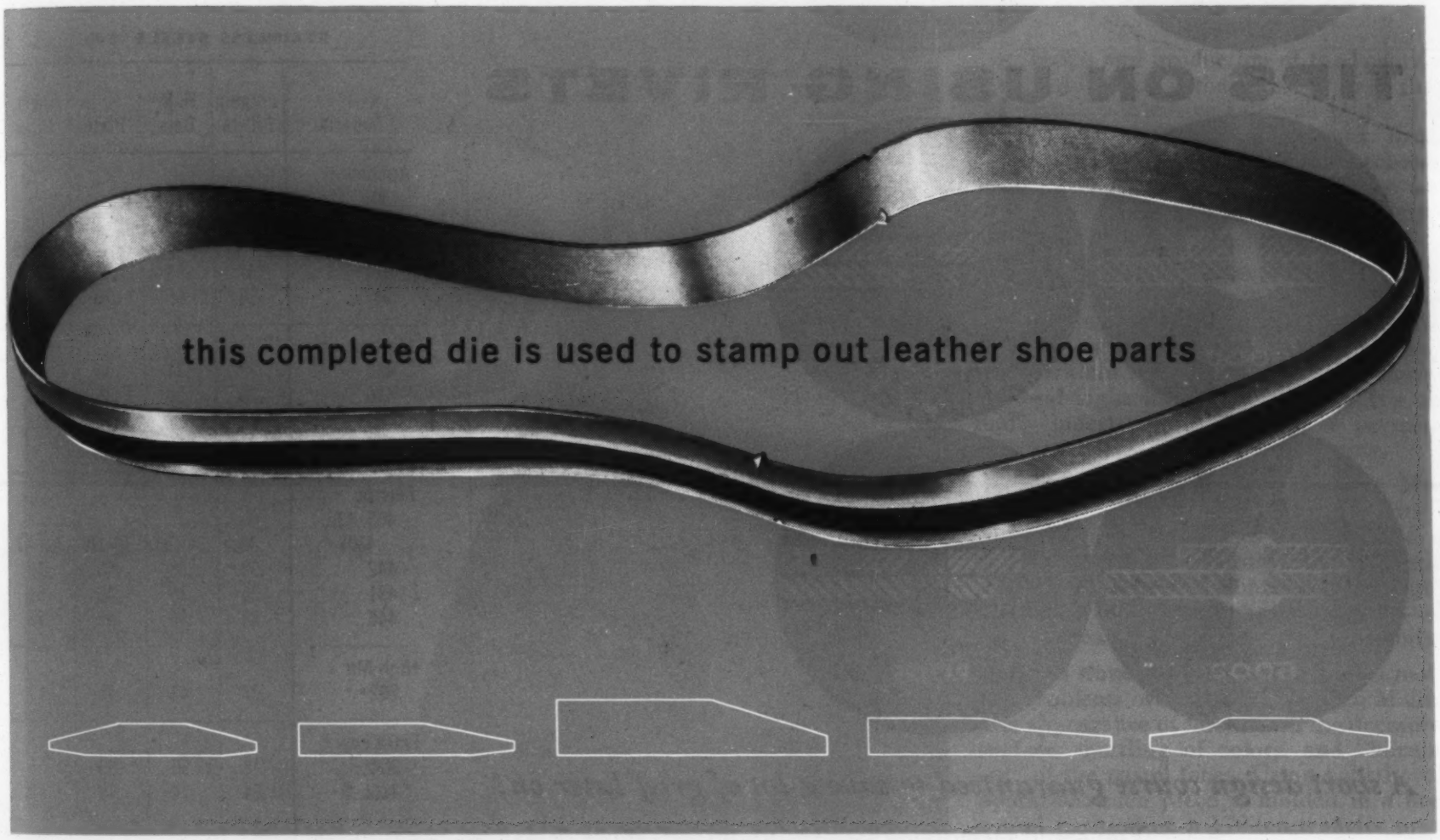
SEMIFINISHED STEEL ($/net ton)

Ingots, Alloy	77
Billets, Blooms, Slabs	
Carbon, Re-Rolling	77.50
Carbon, Forging	96
Alloy, Forging	114
Seamless Tube Rounds	117.50
Wire Rods	$6.15/cwt

(continued on p 222)

CHOOSE CRUCIBLE COLD ROLLED CLICKER DIE STEELS

FOR CLOSE TOLERANCES—FINE FINISH



this completed die is used to stamp out leather shoe parts

Crucible clicker die shapes are cold rolled for better finish, closer size tolerances and minimum decarburization. And their thinner edges require less grinding and filing to complete the die.

What's more, *closely controlled* electric melting gives Crucible alloy clicker die steels maximum toughness, combined with just the right hardness after heat treatment. Edges *stay* sharp, yet are easy to file.

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For shapes and details send for Clicker Die Information Sheets.

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Crucible Steel Company of America

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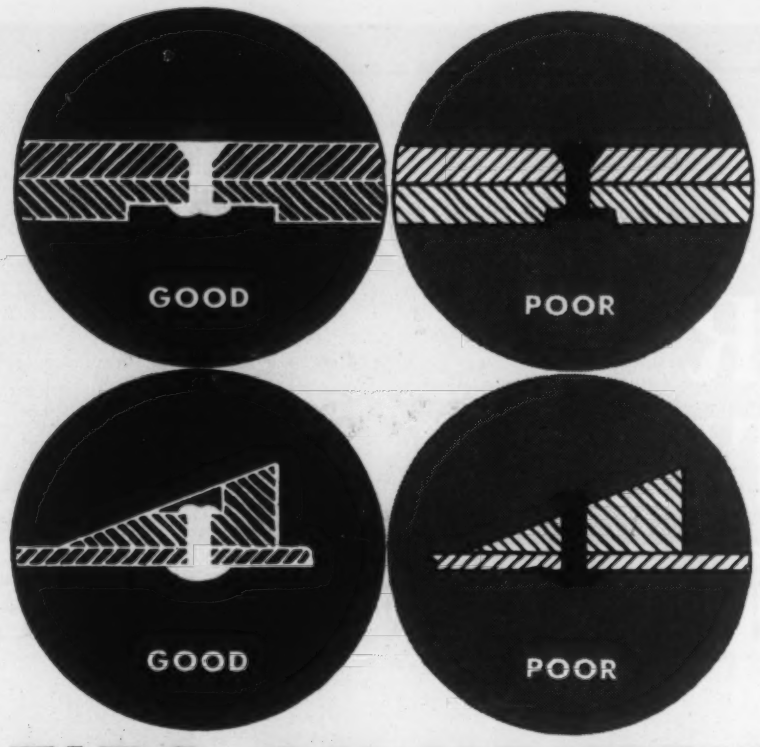

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. . . to take full advantage of automatic assembly
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PRICES AND SUPPLY

FINISHED STEEL ($/cwt)

Form	Carbon	High Str Low Alloy	Alloy
Plate	5.10	7.62	7.20
Sheet, H.R.	4.92	7.27	—
Sheet, C.R.	6.05	8.97	—
Strip, H.R.	4.92	7.32	8.10
Strip, C.R.	7.15	10.65	—
Bar, H.R.	5.42	7.92	6.47
Bar, C.F.	7.30	—	8.77

STAINLESS STEELS ($/lb)

Material	Forging Billets	H. R. Bars	Plate	Sheet, Strip
Austenitic				
301, 302, 302B, 303, 304, 305	.38-.41	.44-.48	.46-.51	.51-.59
321[a]	.47	.56	.60	.66
347[a]	.56	.65	.70	.80
Martensitic				
410[a]	.28	.34	.35	.40
416	.29	.34	.35	.47
403	.32	.38	.40	.48
420, 440	.34	.41	.45	.62
Ferritic				
405, 430, 430F[a]	.30	.34-.35	.36-.38	.41-.47
442	.32	.38	.40	.56
431	.30	.35	.46	.54
446	.38	.45	.46	.67
High Mn				
202[a]	.37	.43	.45	.49
Extra Low C				
304L	.48	.56	.59	.63
316L	.64	.74	.78	.82
Precip Hard.				
17-7PH	.66	.73	.85	.90

[a]Ingot prices approx 60% of forging billet price.

METAL POWDERS ($/lb)[a]

Sponge Iron	.10-.11
Electrolytic Iron	
Annealed (99.5%)	.37
Unannealed (99+%)	.36
Stainless Steel	
304	1.02
316	1.20

[a]Price for —100 mesh.

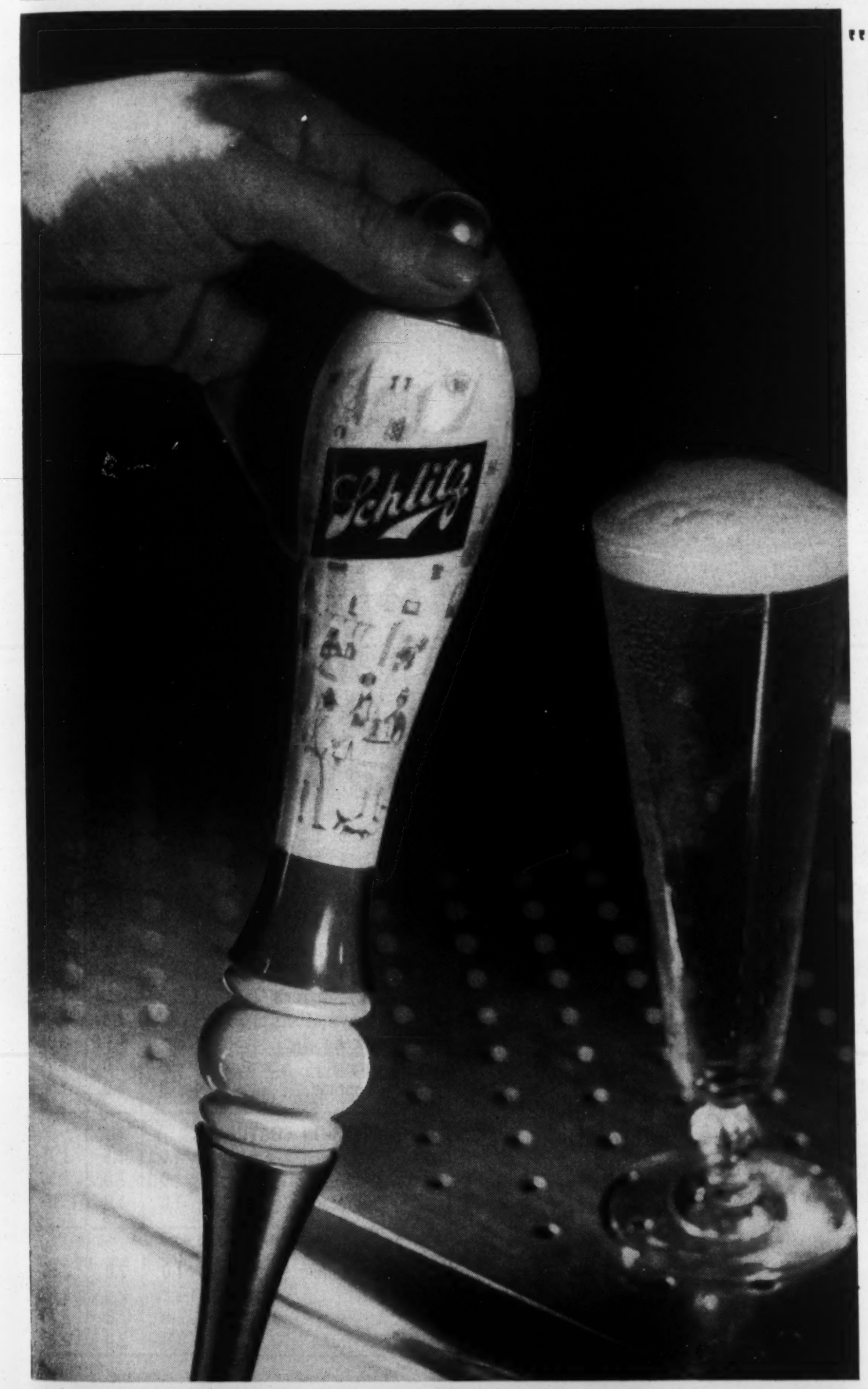
IRON ($/gross ton)

Pig	65-66

(continued on p 224)

Classic decorated porcelain simulated for the first time in

NEW MELAMINE Schlitztap



NEW "SCHLITZTAP" consists of three melamine parts – handle collar, color band, and decorated section. These are assembled on a threaded aluminum rod and held between an anodized aluminum shank and crown. This striking draught-beer sales aid stands a handsome 12" high, carries two gay, five-color village street scenes. It looks like the finest bone china.

"Fused-in" decorations now possible on complex shapes, says Chicago Molded... and here's how it's done:

The design and production of the beautiful new "Schlitztap" is the result of more than two years of intensive research by the Jos. Schlitz Brewing Co., and by Hammer Bros., Inc. A solution to the complex problems involved in molding the tap handles was provided by Chicago Molded who engineered and molded the plastic parts.

A milestone in plastics technology, the "Schlitztap" represents the first time that a compound curved melamine surface has been decorated on a production-line basis. And with this type of decoration, the design is fused right into the melamine. It's virtually indestructible—immune to perspiration, scratching, staining or chipping.

Paves way for new applications. Most important, the "Schlitztap" represents a breakthrough for plastics into the field of decorated ceramics. It suggests parts ranging from decorated containers and giftwares, to lamp bases and door knobs—all made of beautiful, break-resistant melamine.

How it's done. Among the technical molding problems overcome by Chicago Molded was appearance of bubbles on the decorated surface, mottling of colors, and "burning out" of the pastel tones. Using a dual cycle operation, each piece is molded in a horizontal position on a 170-ton transfer press. During the first phase, melamine is forced into the die and allowed to pre-cure. The mold is then opened for positioning of two melamine foil overlays. Then there's a final curing cycle and the decoration becomes an integral part of the completed handle.

Whatever your plastic molding needs, you'll find it pays to call in Chicago Molded. CM engineers keep abreast of the progress in plastics, often *create* that progress to help you make your product more saleable. *That's why 66% of our business comes from firms we've served for over 20 years.*

For your free subscription to Plastics Progress, CM's magazine on up-to-date developments in plastics, write today to:

CHICAGO MOLDED
PRODUCTS CORPORATION
1046 North Kolmar Avenue, Chicago 51, Illinois

For more information, turn to Reader Service card, circle No. 454

● U.S.G. specializes in difficult moldings involving precision tolerances, intricate shapes, delicate wall sections, inserts, molding around metallic structures, etc.

They are equipped with unusual "know how" gained as pioneers and leaders in fluorocarbon plastics fabrication, and the most modern facilities and techniques for cold molding and sintering of TEFLON*, and the injection molding of KEL-F† (as well as nylon, polyethylene, polystyrene and other plastics) in large and small production quantities.

Send us your difficult fluorocarbon molding problems for quotations. They may not be difficult at all for us. Turning them out in our regular stride can mean improved quality at considerable savings in cost.

And call upon us, too, for your requirements of fluorocarbon plastic and nylon sheets, discs, tape, rods, tubing, bars, cylinders, etc. from the world's largest and most complete stocks.

Write for literature and quotations.

United States Gasket Company
Camden 1, New Jersey

**du Pont Trademark*
†Minn. Mining & Mfg. Trademark

United States Gasket *Plastics Division*
OF THE GARLOCK PACKING COMPANY

For more information, turn to Reader Service card, circle No. 403

PRICES AND SUPPLY

CLAD STEELS (¢/lb)[a]

Cladding Metal	10%	15%	20%
Stainless			
304	37.95	42.25	46.70
304L	40.55	45.10	49.85
316L	49.35	54.70	60.10
321	40.05	44.60	49.30
347	42.40	47.55	52.80
430	29.80	33.35	37.25
Inconel	59.55	70.15	80.85
Nickel	51.95	62.30	72.70
Monel	53.55	63.80	74.05

[a]Prices given for three cladding thicknesses

TIN PLATE ($/base box)

Hot Dip (1.25-1.50 lb)	10.05-10.30
Electrolytic (0.25-0.75 lb)	8.75-9.40

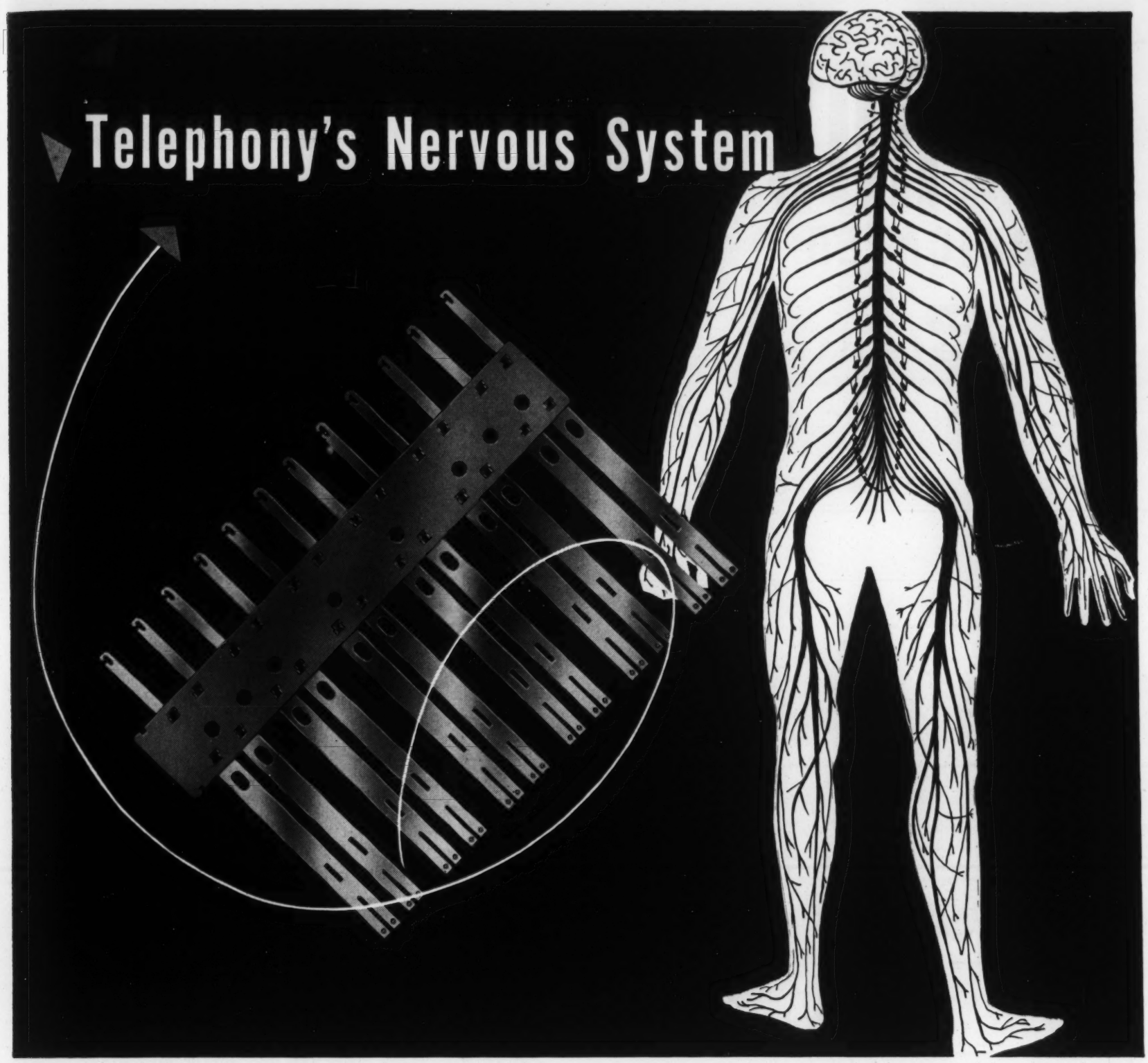
FINISHES AND COATINGS

ORGANIC COATINGS

Material	Avg Thk per Coat, mil	Mils Required[a]	Cost, ¢/sq ft/dry mil[b]
VARNISHES, ENAMELS			
Short Oil Phenolic			
Varnish	1.0	1.0	1.50
Enamel	1.2	1.0	1.75
100% Phenolic	1.0	1.5	1.75
Straight Oil-Modified			
Alkyd	1.5	1.5	1.50
Alkyd-Amine (90-10)	1.5	1.5	1.75
Alkyd-Phenolic (50-50)	1.5	1.5	1.75
Alkyd-Vinyl (50-50)	1.0	2.0	2.0
Alkyd-Styrene (70-30)	1.2	1.5	1.75
Epoxy	1.8	1.8	2.00
Silicone	.5-1.0	.5-1.0	6.0
Furane	2.0	2.0	1.0
Neoprene	5.0	5.0	1.50
DISPERSION COATINGS			
Phenolic	1.0	1.5	1.75
Vinyl	1.0	2.0	2.50
Fluorocarbon	1.0	1.0	15.0
LACQUERS			
Nitrocellulose	1.0	2.0	2.50
Vinyl	1.0	2.0	2.50
Acrylic	1.0	2.0	2.75
Butyrate	1.0	2.0	2.75

[a]Thickness over phosphate coating required for exterior durability on steel. For purely decorative coating, 1 mil will usually suffice.
[b]Materials cost only. Realistic price comparison can be made only on basis of dry applied coating, not on basis of cost per gallon.

(news on p 226)



. . . relies on "neurons" of Seymour Nickel Silver

Dial telephones carry your voice to the ends of the earth through an intricate electrical network which closely resembles the human nervous system. Seymour nickel silver plays a key role in modern communications as part of the North Electric Company "Crossbar Switching System" which automates independent telephone company exchanges.

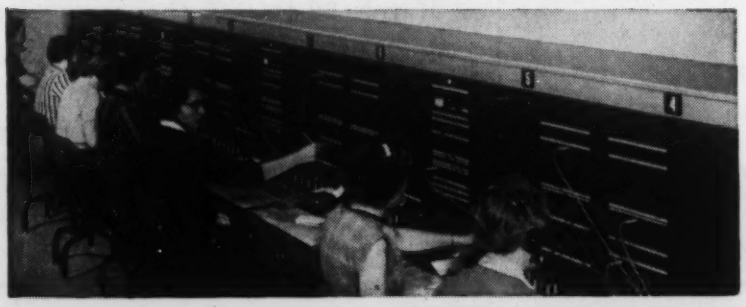
Tiny, neuron-like contacts on North Crossbar switch assemblies rely on flat springs of even-tempered Seymour nickel silver for *trillions* of "makes-and-breaks".

Easy to work, corrosion-resistant and possessing excellent conductivity, Seymour nickel silver has an enviable reputation for quality and uniformity among hundreds of manufacturers who say: —

"Specify SEYMOUR. You KNOW it's good!"

Perhaps Seymour metallurgists can help solve your materials problems. Tell us your requirements.

Long distance telephone operators link distant points to the North Crossbar System in Seymour, Indiana.



THE SEYMOUR MANUFACTURING COMPANY

9 FRANKLIN STREET, SEYMOUR, CONNECTICUT

For more information, turn to Reader Service card, circle No. 435

ROLOCK

FABRICATED ALLOYS

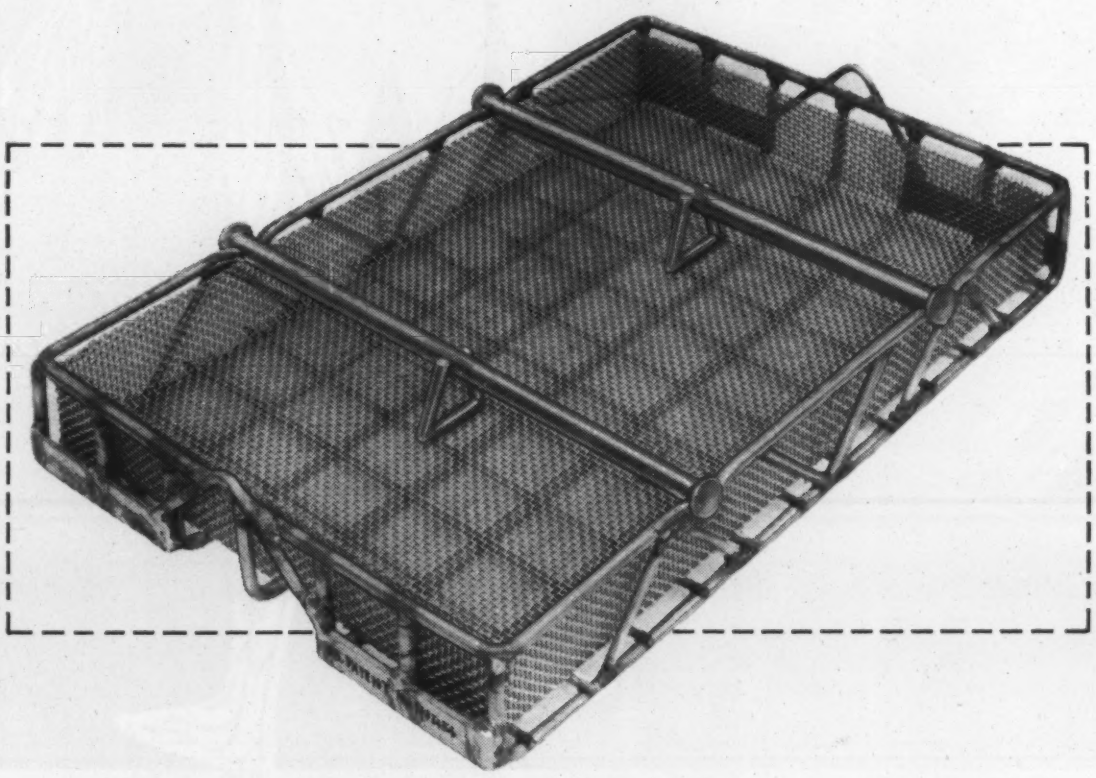
HEAT AND CORROSION RESISTANT

this **Patented** Rolock design

(U.S. Pat. No. 2807454, Sept. 24, 1957)

has changed the whole picture

of furnace tray performance



Originated by Rolock engineers, and now covered by patent, the unique construction of these round-rod sled-type trays has proved so successful that an increasingly large number of them are in service in Ipsen, Lindbergh, Eclipse, and other furnaces with this type of hearth.

Their performance has been exceptional, with hour life greatly extended (sometimes several hundred percent) and per-furnace-hour costs proportionately reduced.

These trays clearly demonstrate the following important advantages in service:—

- Travel easily and smoothly over hearth, with bottom bars acting as sleds.
- When used two-high, stacking bars provide adequate support and also prevent side-slide.
- Live-load to basket weight ratio often better than 10 to 1.
- All-Inconel construction with Rolock-quality precision pressure welding.
- Longer furnace hour expectancy than any other known tray design.
- Lowest cost per hour of use.

Why not enjoy this superior performance and worthwhile operating cost savings? Place your next order for trays with **Rolock**. Also send for catalog of other heat treating equipment.

SALES AND SERVICE REPRESENTATIVES FROM COAST TO COAST

ROLOCK INC., 1282 KINGS HIGHWAY, FAIRFIELD, CONN.

10RL57

JOB-ENGINEERED for better work
Easier Operation, Lower Cost

For more information, turn to Reader Service card, circle No. 539

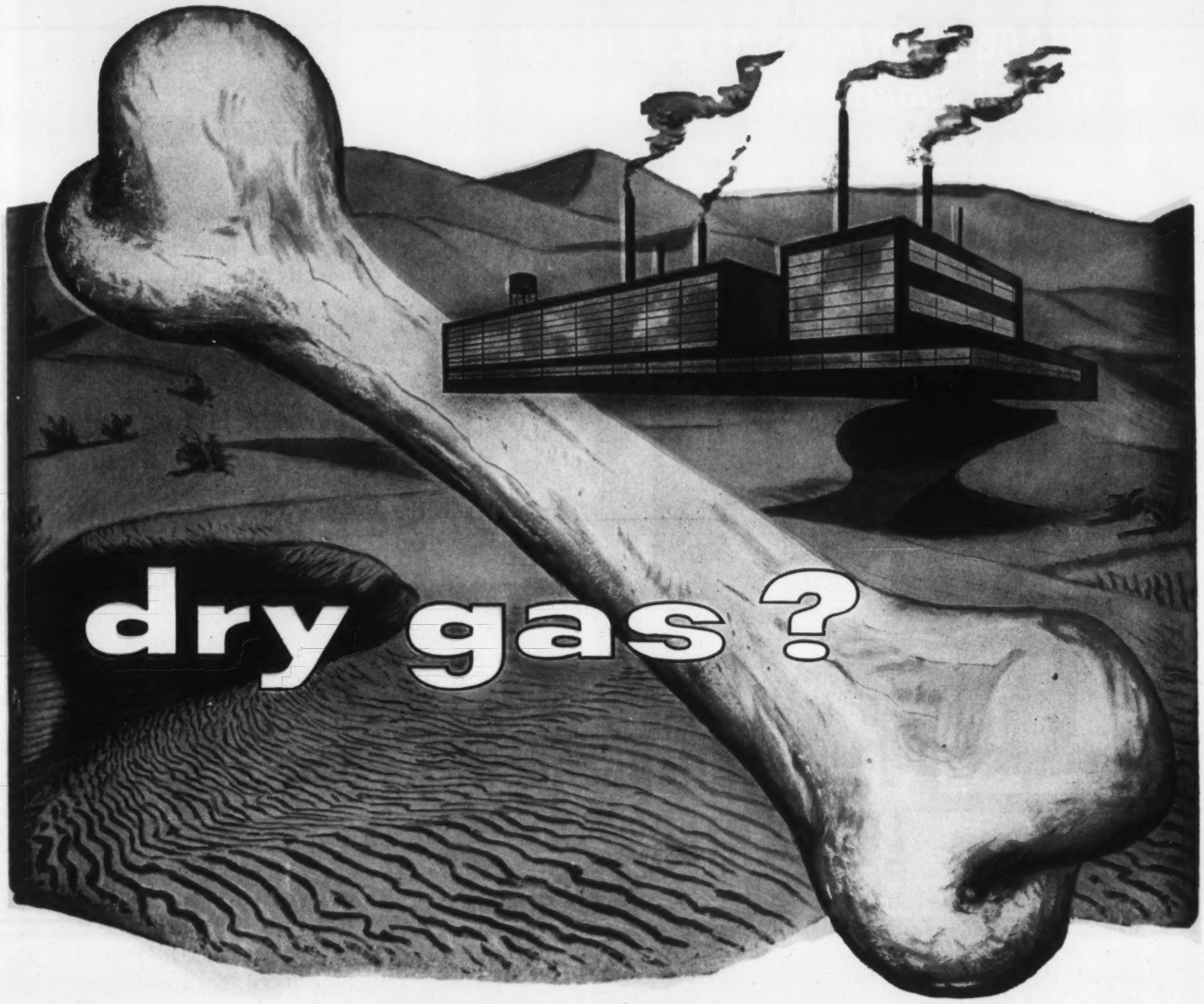
PRICES AND SUPPLY

Copper Prices—cont'd from p 216

labor agreements covering a period of three years. Almost immediately, copper users decided to work off the reserves they had accumulated and for the month of September the ratio of copper to steel fell to 1.002%; for the rest of the year the average amounted to 1.008%. This continued in pretty much the same way through 1957 and the average for the first eight months was 1.101% — just slightly higher. However, statistics show that 142,000 more tons of copper were consumed in the United States in 1957 than were either produced here or imported. This additional amount had to come from users' inventories. In fact, Mr. Glover points out that one of the world's largest electrical equipment manufacturers used its own inventories for approximately 20% of its copper requirements. As a result, many thousands of tons of new copper ended up in producers' stocks—and it was this that accounted for the reduction in prices and abundance of supply.

What's ahead?

The obvious conclusion drawn from all this is that users' inventories will soon be depleted and the present supply-demand situation is bound to reverse. In fact, Mr. Glover believes that the "adjustment period is coming to a close and we will very shortly return to a situation where sufficient production and not sufficient demand is the problem." As a result, copper prices should begin to rise in the near future. When they will rise or how high is not certain. Mr. Glover says that last March 33.1% of the copper production in the United States was produced at a cost of 25¢ per lb and higher, and 22.6% at 29¢ per lb and higher. Since then costs have risen and copper prices have fallen. This much is certain: if the supply-demand statistics pre-

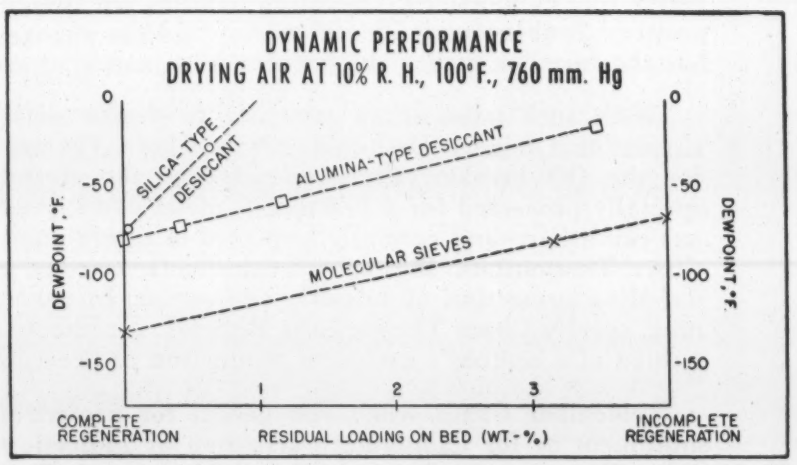


Now you can dry gases drier than dry!

LINDE Molecular Sieves can dry your gases—air, hydrogen, chemical streams—more thoroughly than any other commercial adsorbent. They will duplicate laboratory performances—*in your plant*—under normal *production* conditions.

Even though your gas stream may already be partly dried, Molecular Sieves will remove the last traces of moisture. Only a small volume of adsorbent is required. The same combination of high capacity and low dewpoint is also obtained at high temperatures, up to 200°F.

This is SUPER-drying! Dynamic performance is shown in the accompanying graph. This superior performance also can be expected at higher relative humidities and at other temperatures and pressures. Of particular significance in production is the relative insensitivity of Molecular Sieves to incomplete regeneration.



For further information, write for data sheets on "Drying of Gases." Address Dept. N-12, Linde Company, Division of Union Carbide Corporation, 30 East 42nd St., New York 17, N. Y.

The terms "Linde" and "Union Carbide" are registered trade-marks of UCC.

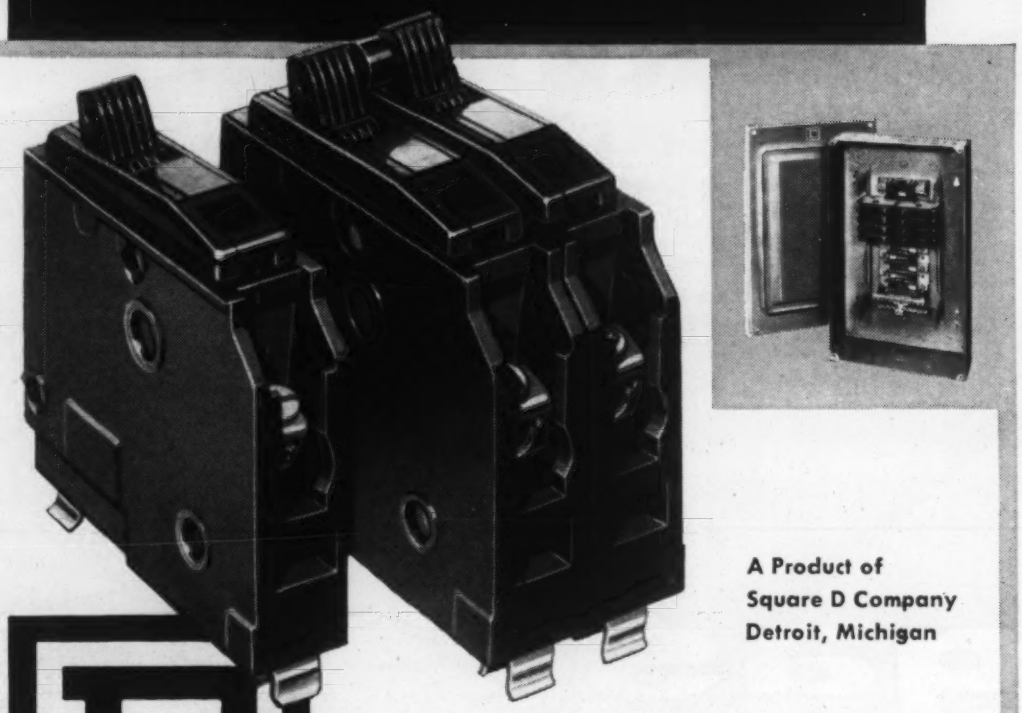
Linde TRADE MARK MOLECULAR SIEVES

UNION CARBIDE

For more information, turn to Reader Service card, circle No. 494

CHACE THERMOSTATIC BIMETAL

ACTUATES ANOTHER PRECISION PRODUCT . . .



A Product of
Square D Company
Detroit, Michigan

QO CIRCUIT BREAKER LOADCENTERS

The QO Loadcenter by Square D Company is typical of the skillful design and fine construction which distinguishes this famous manufacturer's entire line of products. Trip elements are the highly-efficient thermal and independent magnetic type. Overloads are controlled by a direct-heating bimetal element, protected by a special "arc chamber" which completely shields the sensitive bimetal from hot blasts. An auxiliary bimetal element provides temperature compensation against the heat of the sun, furnaces, enclosures, etc. Silvered plug-in jaws and silvered connectors are used to provide better line connections. Operating handles are designed for quick, positive trouble-circuit identification. And the swing-grip mounting lets the installer mount the breaker in a matter of seconds.

With such painstaking attention to design details, it is only natural that Square D should specify Chace Thermostatic Bimetal for the QO breaker. Precision-rolled to the closest tolerances — specially processed for a *permanent* metal bond—tested under various conditions—and carefully inspected to assure quality of product, Chace Thermostatic Bimetal provides instantaneous, automatic, and unfailing protection of valuable equipment. In *your* product planning, specify Chace Thermostatic Bimetal . . . ultimate result of over a third of a century's exclusive production of precision bimetal.

Remember Chace when you design for protection of valuable equipment or for temperature actuation or indication. Dependable Chace Thermostatic Bimetal is available in over 30 types, in strip, coil or completely fabricated and assembled elements made to your specification. (We do not manufacture complete controls or any other devices in competition with our customers.) Write today for new 44-page booklet, "Successful Applications of Chace Thermostatic Bimetal", containing many pages of design data.

IT BENDS WITH THE HEAT

W. M. CHACE CO.
Thermostatic Bimetal
1615 BEARD AVE., DETROIT 9, MICH.

For more information, turn to Reader Service card, circle No. 516

sented here are correct, the price of copper must be increased sufficiently soon and sufficiently high in order for these mines to continue producing.

What's Happening in Prices and Supply

Polyester—Du Pont has reduced prices of most types of Mylar polyester film by 25¢ per lb. The reductions apply to all coated and heat-shrinkable types and to types A and D in all gages. No change was made in the price of type C. This fourth price reduction since the start of commercial operations three years ago brings the price to the range of $2-4 per lb, with the thinner gages more expensive.

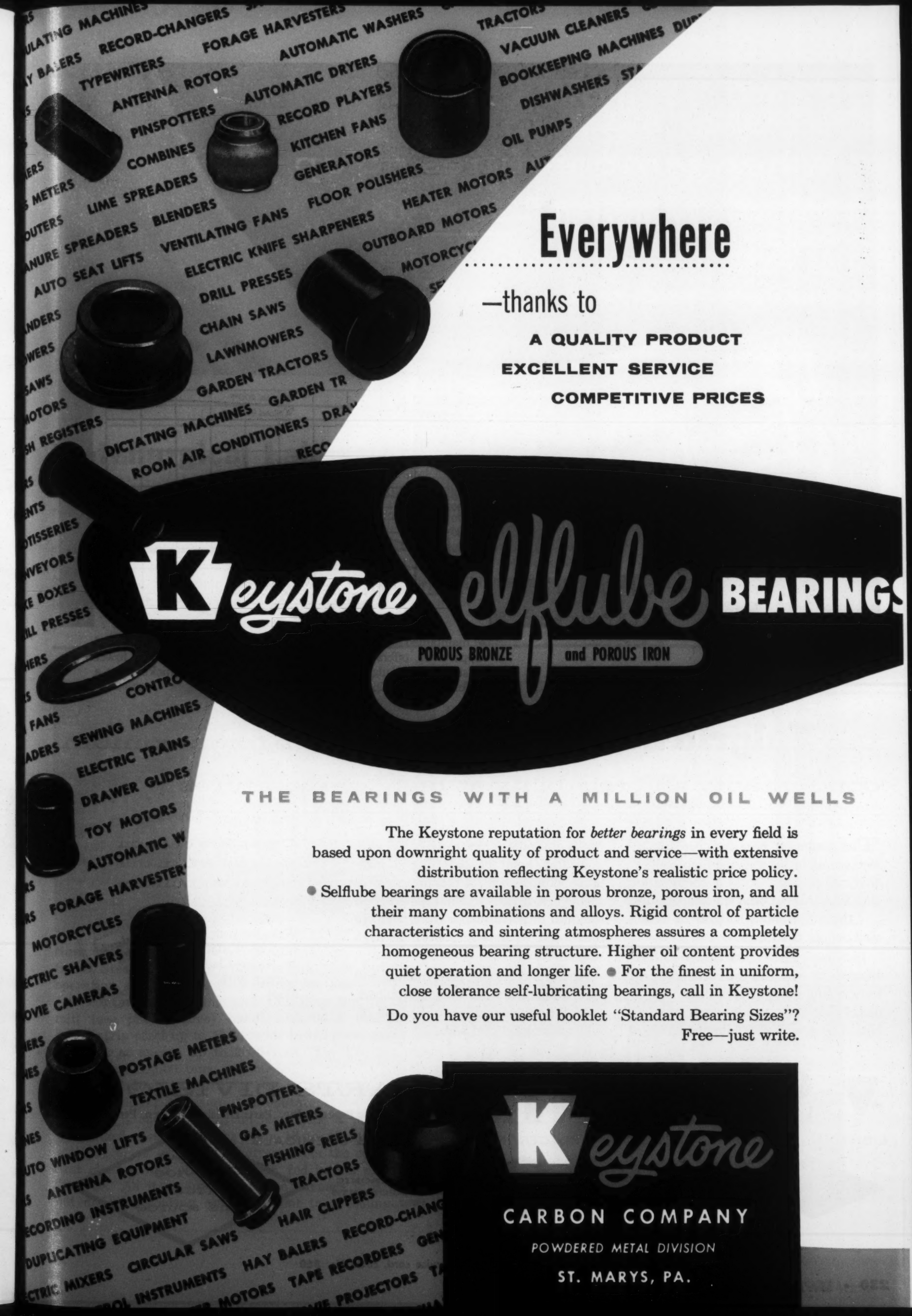
Cellophane—Prices of K-202 and K-203 polymer-coated cellophane have been reduced 5¢ per lb by Du Pont, bringing the price to 79¢ per lb. Du Pont has also announced that its 300-gage K-203 cellophane, a new thin-gage material which had been classed as experimental, has been added to the standard line and is now commercially available.

Cellulose acetate — Eastman Chemical Products, Inc., has announced a 3¢ across-the-board increase in the price of its cellulose acetate flake.

Polyether foam—General Tire and Rubber Co. has put its relatively new material, polyether-based urethane foam, into volume production. At the same time, General says it has discontinued production of conventional polyester-based urethane foams.

Cobalt 60—Nuclear Systems, a division of Budd Co., has reduced the price of cobalt 60 sources sold commercially for research, development and for industrial applications of radioactive materials. The price reduction amounts to 50-70%.

For more information, circle No. 534



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A QUALITY PRODUCT

EXCELLENT SERVICE

COMPETITIVE PRICES

Keystone Selflube BEARINGS

POROUS BRONZE and POROUS IRON

THE BEARINGS WITH A MILLION OIL WELLS

The Keystone reputation for *better bearings* in every field is based upon downright quality of product and service—with extensive distribution reflecting Keystone's realistic price policy. ● Selflube bearings are available in porous bronze, porous iron, and all their many combinations and alloys. Rigid control of particle characteristics and sintering atmospheres assures a completely homogeneous bearing structure. Higher oil content provides quiet operation and longer life. ● For the finest in uniform, close tolerance self-lubricating bearings, call in Keystone!

Do you have our useful booklet "Standard Bearing Sizes"? Free—just write.

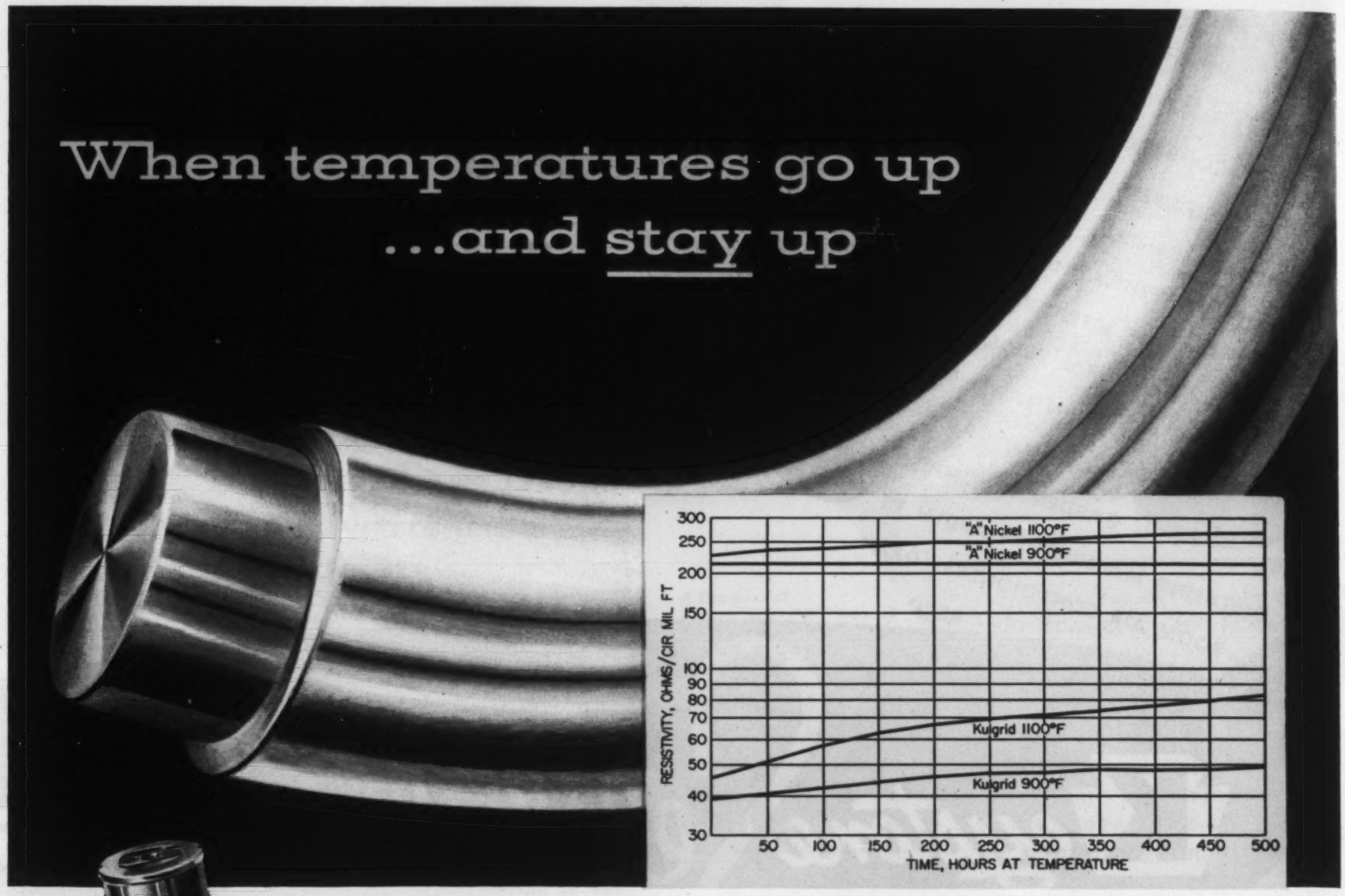
Keystone

CARBON COMPANY

POWDERED METAL DIVISION

ST. MARYS, PA.

When temperatures go up ...and stay up



At maintained high temperatures, Kulgrid 28, Sylvania's nickel-clad copper wire, offers the temperature stability of nickel with lower resistivity. Yet Kulgrid 28 is less expensive than pure nickel from a performance standpoint.

Use **Kulgrid 28**® nickel-clad copper wire for maximum conductivity and reliability at high temperatures

THE STRENGTH, heat and corrosion resistance of nickel and the high conductivity of copper . . . in a combination that *beats both* at elevated temperatures . . . that's Sylvania's Kulgrid 28 nickel-clad copper conductor.

In diameters from .300" down to .0035" Kulgrid 28 wire has the corrosion protection and strength of a thick wall of nickel that only cladding can provide. Nickel content is approximately 28%.

Made of Grade A electronic nickel with a melting point of 2651°F and high-purity copper, with a melting point of 1980°F, Kulgrid 28 offers you a new standard of performance for equipment that must withstand sustained high temperatures.

Wherever economy, performance, and high temperature are design problems, check the unique qualities of Kulgrid 28, Sylvania's nickel-clad wire.

Complete data on Kulgrid 28 in this technical bulletin

Write for your free copy of "Kulgrid 28, Nickel-Clad Copper Wire" today.

SYLVANIA PARTS DIVISION

Sylvania Electric Products Inc., Parts Division, Warren, Pennsylvania

LIGHTING • RADIO • TELEVISION • ELECTRONICS • METALS & CHEMICALS

SPECIAL WIRE · METAL STAMPINGS · MOLDED PLASTIC · ELECTRONIC COMPONENTS

4-way service from one source

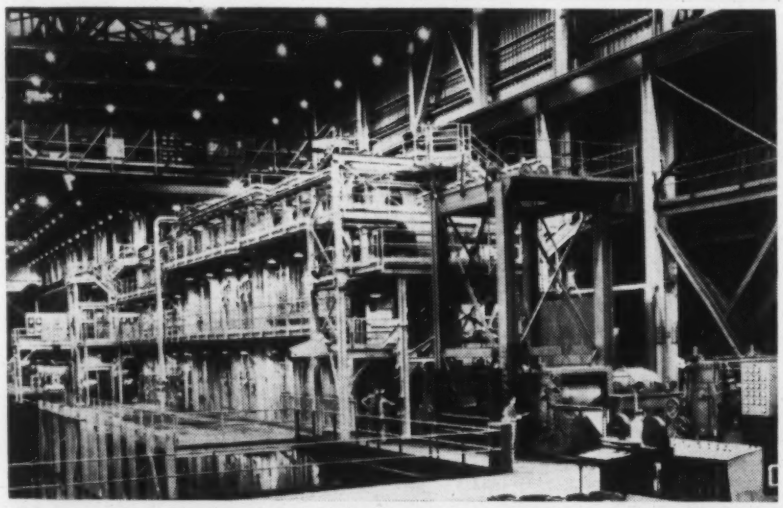
For more information, turn to Reader Service card, circle No. 560

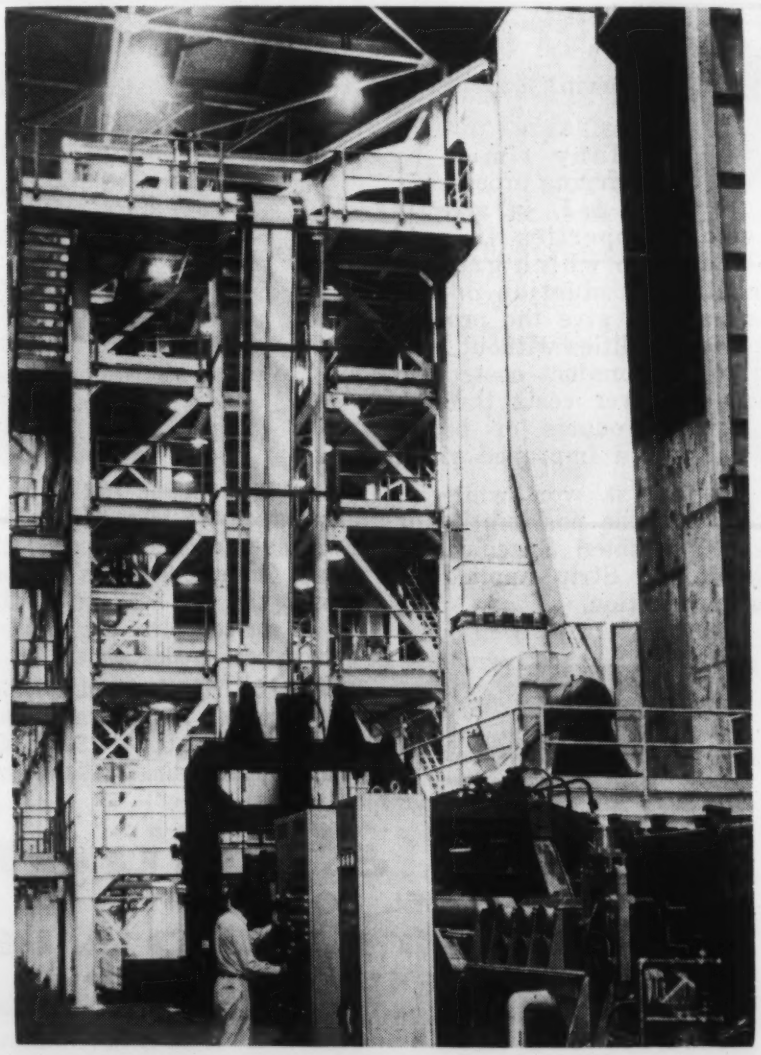
News OF INDUSTRY

Metallurgical Laboratory Tests New Materials

■ A new metallurgical and materials testing laboratory that is equipped to handle virtually any engineering material, has been built by Caterpillar Tractor Co. Some of the materials presently being tested include ferrous and nonferrous castings, forgings, bar stock and tubing, as well as rubber, cork, plastics, paints, oils, solvents and fibers. In general, research is aimed at evaluating new materials, establishing testing techniques, prescribing specifications, solving manufacturing problems and developing new applications.

The new laboratory is divided into several separate sections, each of which performs specific functions. In the physical testing





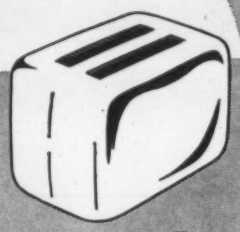
New steel facilities—Weirton Steel Co., Div. of National Steel Corp., has placed several new facilities in operation at its plants in Weirton, W. Va.

A continuous cleaning and annealing line in the tin mill (see photo above) handles 60,000-lb coils of cold rolled strip steel up to 45 in. wide in tin plate gages, and operates at speeds up to 2000 fpm. The line can clean and anneal 20,000 tons per month.

A continuous galvanizing line in the sheet mill (see photo at right) is designed to operate at 300 ft per min max and is capable of producing 12,000 lb per month of galvanized steel in widths from 18 to 48 in. The strip steel, received in coil form direct from the cold mills, is first cleaned and sized and then fed into a preparation furnace. As it emerges from the furnace it is given a hot dip zinc coating and then sent to a cooling tower.

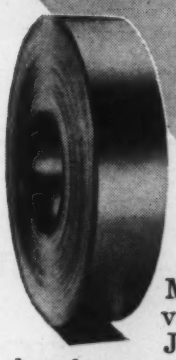
J&L
RESTRICTED SPECIFICATION
COLD ROLLED STRIP STEEL

SIZE	8 x .045
ANALYSIS	1010
FINISH	#2 finish
HARDNESS	Non-Scalloping quality
THICKNESS TOLERANCE	± .0005 Incl. crown
WIDTH TOLERANCE	± .005
COIL SIZE	250# per inch of width
PACKAGING	Skidded



SIZE	12 x .032
ANALYSIS	1010
FINISH	#3 finish
HARDNESS	#4 Temper
THICKNESS TOLERANCE	± .0005 Incl. crown
WIDTH TOLERANCE	± .005
COIL SIZE	up to 200# per inch of width
PACKAGING	Paper inter-leaved—skidded and shrouded

Serves Typical Low Carbon End Use Requirements Such as these . .



SIZE	4 x .065
ANALYSIS	1010
FINISH	#2 finish
HARDNESS	#3 Temper
THICKNESS TOLERANCE	± .0005 Incl. crown
WIDTH TOLERANCE	± .005
COIL SIZE	Cut lengths
PACKAGING	Skidded

Many times, by varying processing, J & L is able to develop properties in cold rolled strip which greatly facilitate production operations and/or give the product superior qualities without adding to end product cost. End result is lower costs through improved products or better assembly and improved yield.

We believe it worthwhile to investigate the possibilities of J & L Restricted Specification Cold Rolled Strip applied to your production.

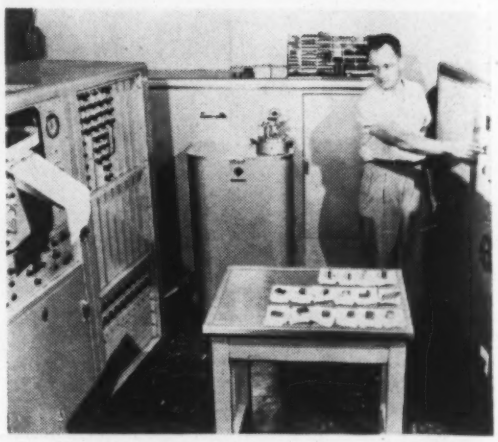
THE 4 IN 1 SOURCE FOR COLD ROLLED STRIP STEEL
Now there are four J & L plants with facilities for production of "Restricted Specification" cold rolled strip. Strategic locations at Youngstown, Indianapolis, Los Angeles, and Kenilworth, N. J., provide the security of 4 sources plus the close working relationship which local production centers make possible.

J & L STRIP STEEL DIVISION PRODUCTS
Low Carbon, High Carbon, Annealed or Hardened and Tempered Spring Steel, Electro Galvanized or Hot Dipped Continuous Galvanized, Tin Coated, Alloy, Stainless.

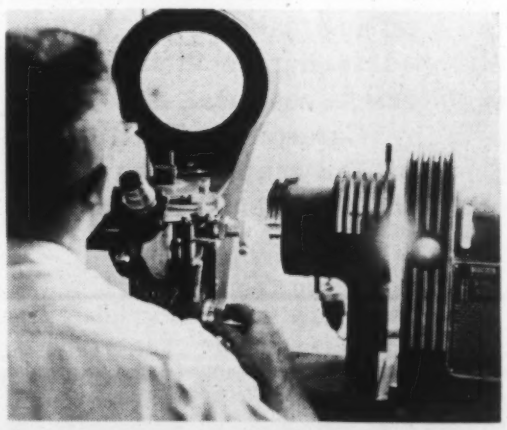
Jones & Laughlin
STEEL CORPORATION
STRIP STEEL DIVISION
GENERAL OFFICES: YOUNGSTOWN 1, OHIO
PLANTS: YOUNGSTOWN • INDIANAPOLIS • LOS ANGELES • KENILWORTH, NEW JERSEY
SALES OFFICES: NEW YORK • ROCHESTER • NEWINGTON, CONN. • YOUNGSTOWN • CLEVELAND
DETROIT • INDIANAPOLIS • CHICAGO • LOS ANGELES • SAN FRANCISCO
FORMERLY THE COLD METAL PRODUCTS COMPANY

For more information, turn to Reader Service card, circle No. 452

News OF INDUSTRY



Analyses of metal *samples are determined by quantometer in spectrographic laboratory.*



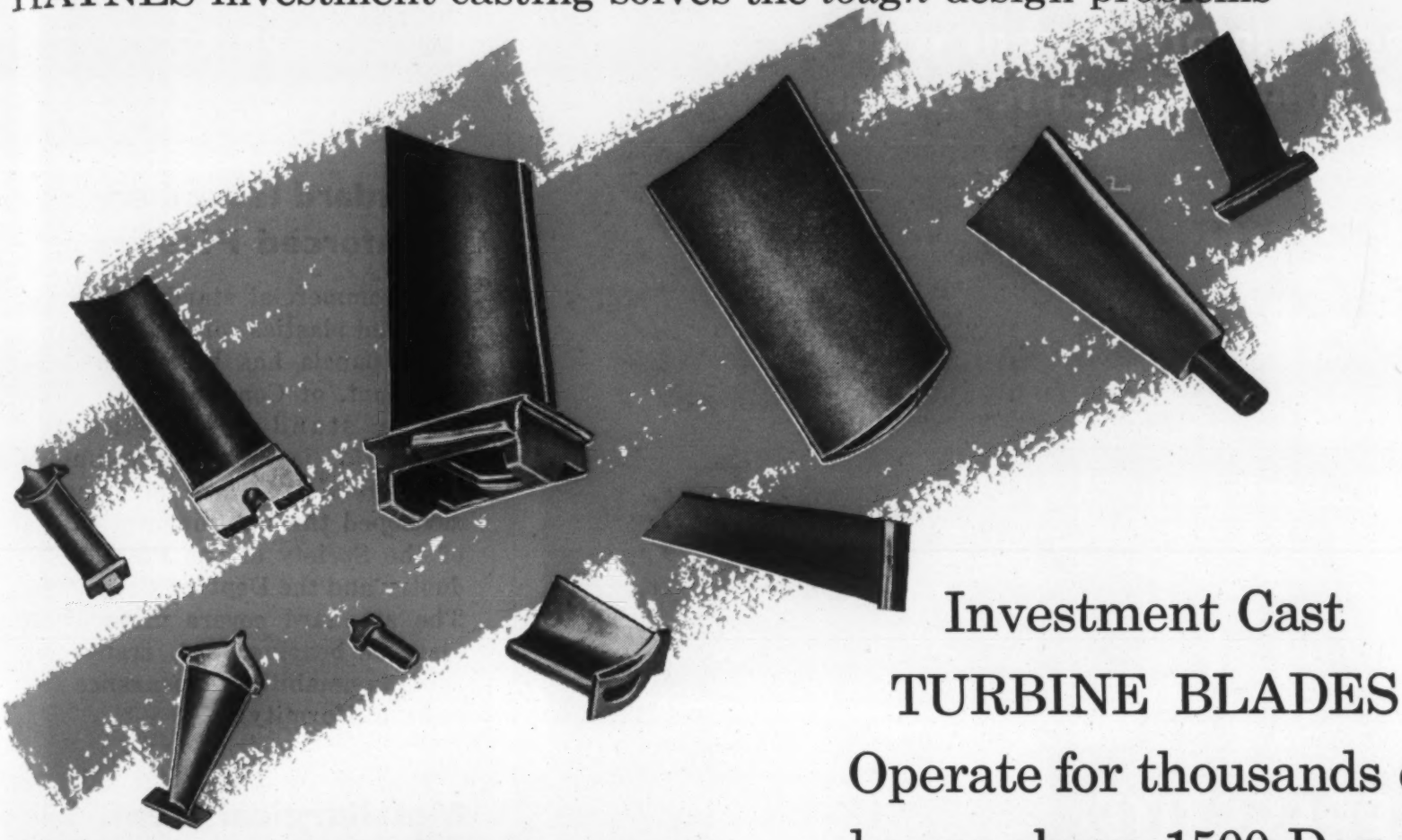
Structure of steel *sample is inspected in metallographic viewer.*

laboratory, for example, materials are tested to determine hardness, impact resistance, tensile strength, etc. In the spectrographic section, spectrographs and quantometers are use to make chemical evaluations of steel. In the paint laboratory, a weatherometer is used to intensify weather conditions so that tests that would require years under normal conditions are performed in only 1000 hr. The chemistry laboratory is responsible for the development and improvement of electroplating, phosphate pickling, wash tank solutions, rust preventatives, machine coolants and heat treat solutions.

Other sections of the laboratory include the rubber section, the concrete laboratory and weld testing section. The laboratory is a 22,000-sq ft building designed for a staff of 150.

(more News on p 234)

HAYNES investment casting solves the *tough* design problems



Investment Cast TURBINE BLADES Operate for thousands of hours above 1500 Deg. F

The age of supersonic aircraft has created a demand for intricately-shaped turbine blades that have excellent strength and low creep rates at high temperatures. Blades made of HAYNES Alloys meet these requirements and that is why they are used in the fastest gas turbine engines. To mass-produce these blades, HAYNES' investment-casting method has proven the economical answer. Compressor blades, vanes and other aircraft components are also efficiently produced by this modern method. For complete information, write for the booklet "HAYNES' Investment-Casting." Address Haynes Stellite Company, Division of Union Carbide Corporation, General Offices and Works, Kokomo, Indiana.

. . . Testing for soundness – Sample castings of every part produced are X-rayed, as part of the normal inspection procedures set up to insure top quality. This test helps to check foundry practices and also makes sure that the part will meet the necessary requirements for soundness.

HAYNES
ALLOYS
HAYNES STELLITE COMPANY
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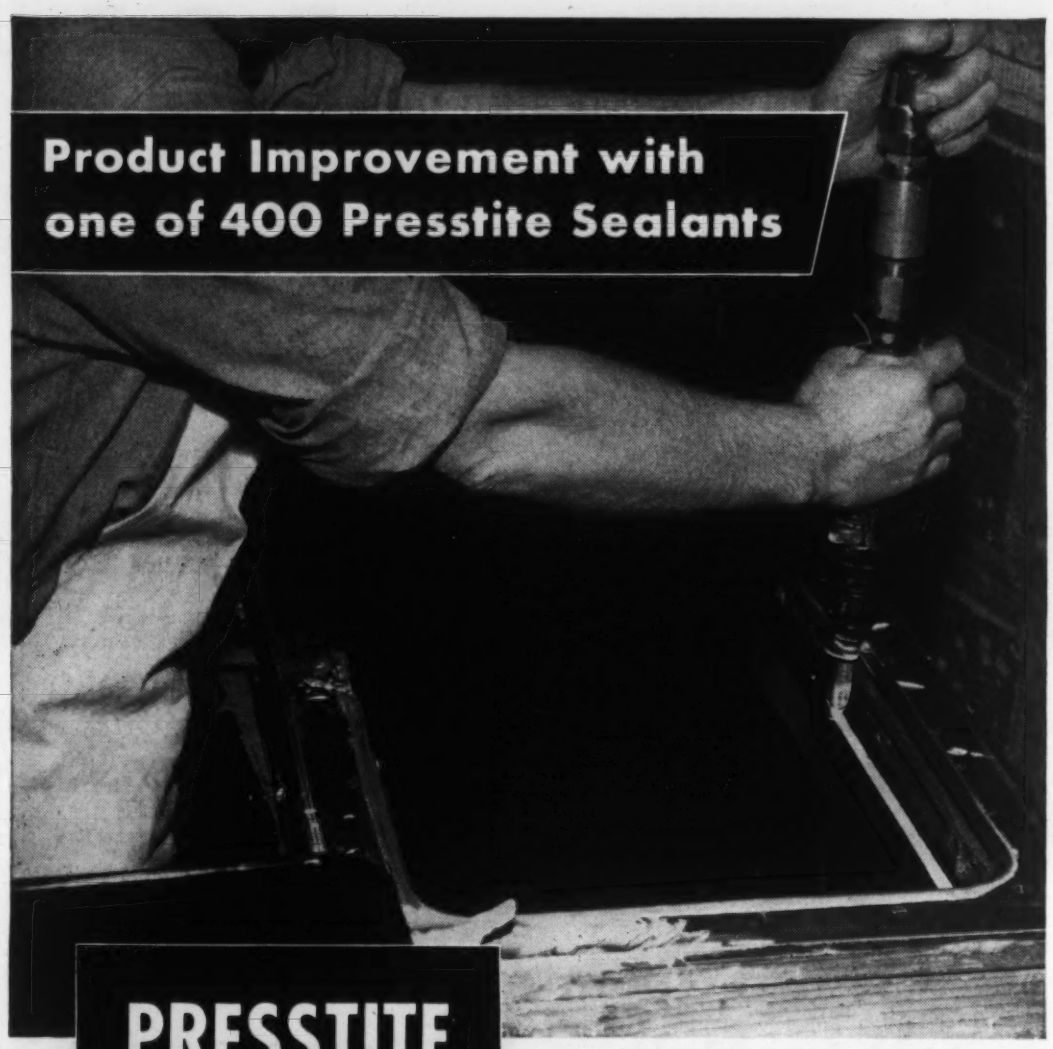
For more information, turn to Reader Service card, circle No. 465



PRESSTITE *Plastisol Sealers* are **TOUGH** COHESIVE **ELASTIC**

Excellent Seal Against *Water, Moisture, Dust*

These modern sealants consist of 100% solid materials. When subjected to proper heat, they cure to a tough elastic body, having excellent adhesion to clean metal surfaces. They are free from contaminating odors.

Other characteristics:

- *In pumpable form* from thick to thin consistencies. Tan, green-yellow, off-white colors.
- *Resistant* to alcohols, aliphatic hydrocarbons, oils, dilute acids (milk), alkalies. Highly resistant to water and moisture vapor.
- *Highly stable,* non-staining.

DESCRIBE YOUR NEEDS... for free working sample best suited to your job.

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PRESSTITE-KEYSTONE ENGINEERING PRODUCTS COMPANY
KAP

A Division of AMERICAN-MARIETTA COMPANY
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For more information, turn to Reader Service card, circle No. 404

News OF INDUSTRY

Standard Issued on Reinforced Plastics

A commercial standard for reinforced plastics corrugated structural panels has been issued by the Dept. of Commerce.

The standard, designated CS-214-57, is the tenth voluntary commercial standard on plastics developed through the joint efforts of the Society of the Plastics Industry and the Dept. of Commerce. The standard covers methods of test for bearing load, transverse load, flammability, appearance and color uniformity.

Metallurgical Dept. Formed at Stanford

As a result of a five-fold increase in enrollment over the last five years, Stanford University has formed a new Department of Metallurgical Engineering. Metallurgical activities were previously combined with those in mining and petroleum engineering.

In addition to the new department, graduate research has been expanded to include: 1) work on diffusion kinetics in polyphase systems in which a dispersed second phase is being formed; 2) a fundamental study of the factors that control the creep strength of brazed joints; and 3) studies of the mechanism by which dispersed phases affect creep behavior of grain boundaries at elevated temperatures.

Research in Steel Aimed at Space Travel

The role of steel in solving problems of space travel is now being actively studied at U.S. Steel Corp.'s Research Center in Monroeville, Pa. According to U.S. Steel, no one yet knows exactly what combinations of properties the ultimate steels for

Johns-Manville presents a

NEW REFRACTORY FIBER INSULATION

for temperatures to 2000° F

DENSITIES, SIZES & THICKNESSES

Type	Density lbs. per cu ft		Available Thickness inches		
CRF300	3	1/4	1/2	3/4	1
CRF400	4	1/4	1/2	3/4	1
CRF600	6	1/4	1/2	3/4	1
CRF800	8		1/2	3/4	1
CRF1000	10		1/2	3/4	
CRF1200	12		1/2		

STANDARD SIZES:
Length: Regularly furnished in 3, 4, 5, 6 and 8 ft. lengths. CRF300 through 800 (except in 1" thickness) also furnished in 26 ft. lengths.

Width: 42 inches (untrimmed).

In loose fiber form the material is known as J-M CERAFIBER; shipped 10 lbs. per bag.

J-M CERAFELT insulation . . .

controls heat more effectively in a wide variety of high-temperature industrial services!

Cerafelt® is one of the most recent achievements of Johns-Manville insulation scientists . . . developed specifically for the new high-temperature processes now being employed in the metallurgical, chemical, ceramic and allied industries.

Particularly important in these applications is Cerafelt's infra-red opacity, an advantage that accounts for its unusually low *k* factor at elevated temperatures. Another important advantage is fineness of fiber structure. With fibers averaging only 3 microns in diameter, Cerafelt contains far more heat-blocking air pockets per cubic inch. Hence, it offers far better insulating effectiveness at high temperatures!

Cerafelt is non-alkaline, chemically stable, and contains no corrosion-promoting agents. For information write to Johns-Manville, Box 14, New York 16, N. Y.
In Canada, Port Credit, Ontario.

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News of Industry

space craft must possess. They do know, however, that the special steels will be required to retain strength at temperatures above 1000 F. A long range program has been initiated to develop special types of steels for the following components: skin and structural members, fasteners, landing gear, bearings and power plants. In order to develop these steels, research is being carried out along three general lines:

1. Establishing the kinds and quantities of alloying elements necessary in a steel to withstand service that may involve heat, cold, vibration, chemical attack, shock or other destructive influences.
2. Determining the manner of shaping the steel into forms that will meet the designer's needs.
3. Developing special heat treatments.

Aluminum Foil Lab First of Its Kind

What is claimed to be the nation's first fundamental aluminum foil and packaging research facility has recently been opened by Aluminum Co. of America.

According to Kent R. Van Horn, director, "Entirely new concepts in the foil field will be explored thoroughly. We intend to investigate and evaluate every aspect of aluminum foil, from the structure of the metal itself to the thousands of untried adhesive, coating, paper, lamination and design possibilities."

The new laboratory is already at work on many new applications of foil in the construction, electrical, home decorating, food processing, printing, packaging, pharmaceutical and other industries. Projects for the future include exploring the feasibility of using foil wall coverings for heating purposes and determining the practicabilities of solar heating.

(News of Engineers on p 238)

when buying
copper or
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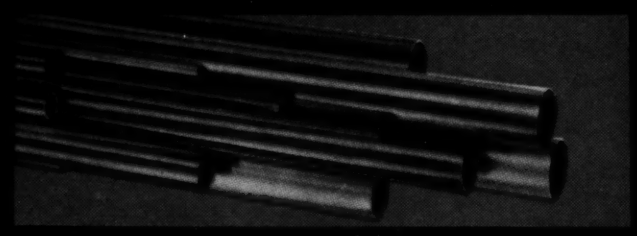
alloy tubing
remember

TEMPER

it should
be tuned
to the task!



The right temper for the task can mean the difference between success or failure, profit or loss. But, relax! Whatever your requirements, specify United seamless copper or copper base alloy tubing. Do so with confidence that the industry's finest quality and production control systems will deliver tubing drawn precisely to your specifications . . . for temper, size, gauge, grain structure, cleanliness, dimensional perfection and cost!

You pay no more for this quality! United tubing, the finest in copper and copper base alloy, is available in coils, straight mill lengths or cut to your specifications.

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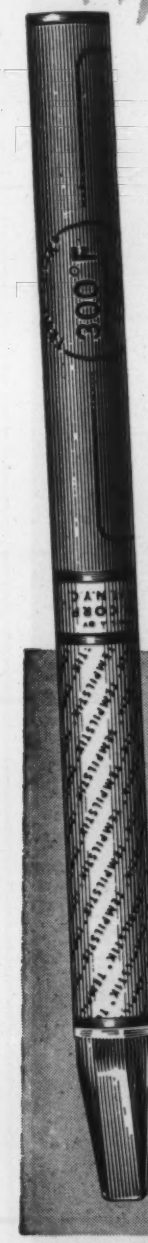

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Accuracy within 1% of rated melting point.

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☐ Send sample pellets for _____°F temperature

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City_____
State_____

For more information, circle No. 383

News OF INDUSTRY

Engineers

Sir Robert A. Watson-Watt, radio-physicist of Toronto, Ontario, Canada, will be the recipient of the Elliott Cresson Medal of the Franklin Institute. He is cited for "his conception of pulsed radar for the vital air defense of Great Britain, for his solutions of important technical problems, and for his inspiring leadership which resulted in the timely development of these radar systems."

J. F. Biggane, manager of industrial engineering, Maytag Co., has been elected to the advisory council on industrial engineering of the National Industrial Conference Board.

Edwin T. Asplundh has been elected chairman of the board, Pittsburgh Plate Glass Co.

John A. Kriva has been named manager — manufacturing engineering, Industrial Div., Warner Electric Brake and Clutch Co.

Lionel H. Orpin has been named director of plans and programs, a newly created position at Stromberg-Carlson, Div. of General Dynamics Corp.

Kenneth M. Miller has resumed his position as manager of engineering at Lear, Inc. LearCal Div., after spending a year on a special assignment.

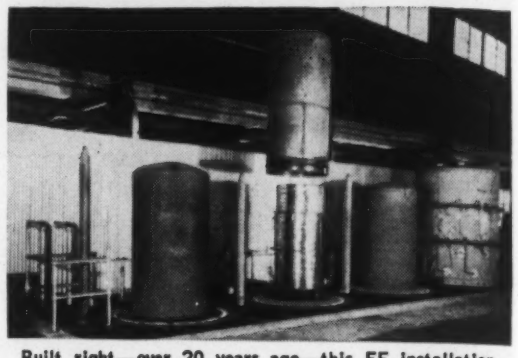
Dr. Robert W. Lindsay has joined the research staff of Crucible Steel Co. as supervisor of constructional alloy steels.

William H. Santschi and **Kenneth B. Higbie** have moved to the Beryllium Corp. as associate directors of research. Santschi is in fabrication metallurgy and Higbie in process and extractive chemistry and metallurgy.

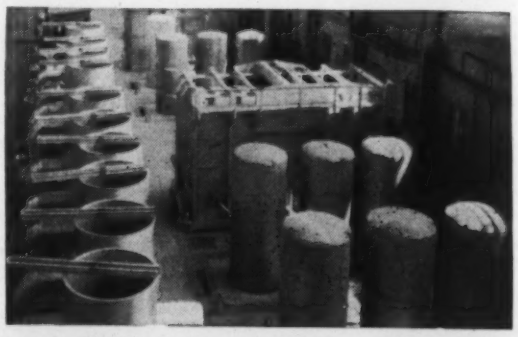
Jose D. Dominguez, president of Puerto Rico Telephone Co., has been appointed executive engineer for the telephone and radio operating dept. of International Telephone and Telegraph Corp.

Elmer R. Queer, director and professor of engineering research, Pennsylvania State University, has been

EF
Bell Type FURNACES
Built to Suit Your Plant, Product or Process



Built right—over 20 years ago—this EF installation is still in operation, daily—and producing first class work.



Part of another installation of large EF gas fired three-stack rectangular bell type forced circulation special atmosphere furnaces for annealing steel strip.

- Single or multi-stack—circular, rectangular or square types — upright, elevator or partial pits—gas fired, oil fired or electric—correctly designed, built and installed, ready to produce.

Backed by over 40 years of practical furnace building experience, EF furnaces incorporate all the advantages of all bell type designs, for processing strip, wire, rod and other ferrous and non-ferrous products.

EF bell type furnaces installed over 20 years ago are still in service daily, producing first class work. There's no substitute for experience.

Submit your production furnace problems to experienced EF engineers—it pays.

BULLETIN No. 461
shows typical installations of EF Gas-fired, Oil-fired and Electric Furnaces
Send for a copy today!

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GAS-FIRED, OIL FIRED AND ELECTRIC FURNACES FOR ANY PROCESS, PRODUCT OR PRODUCTION

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This is the house that **BETTER CLEANERS BUILT!**

Twenty-five years ago Northwest Chemical Company was founded with the express idea of supplying BETTER cleaners to the trade. Today, thanks to a steadfast adherence to the policy of top quality ingredients carefully blended with mature experience and pleasingly flavored with good service, Northwest has attained a position of respected leadership in the cleaner field.

A cleaner is only as good as the house behind it. Today's fast changing materials and methods quickly obsolete yesterday's products and create a need for completely new types of cleaners.

Northwest's continuing research program offers our customers the BEST advanced thinking, no matter what the problem. You are paying for Northwest's plus values wherever you buy. Why not avail yourself of them?

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LO-HI pH

NORTHWEST CHEMICAL CO.

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pioneers in pH cleaning control *serving you since '32*

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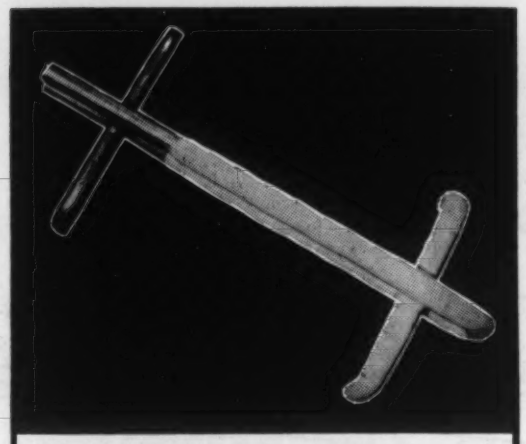

PLATING RACK COATING

Why does Reynosol boast one of the nation's best reputations as a plating rack coating and primer—*in all known plating solutions?*

Because REYNOSOL guarantees easy air release high gloss, and—important to you—*quick fusion.* For REYNOSOL customers, this means high quality... *plus* economies that have previously been impossible.

Look at these general specifications—and write today for complete information on REYNOSOL rack coatings and primers:

COLOR	Unlimited
WEIGHT	Sp. gr. = 1.20 -or 10 lb. per gal.
TOXICITY	Can be formulated to be non-toxic
AGING PROPERTIES	Good
LIGHT RESISTANCE	Good
TYPE OF SURFACE	Dry and glossy
TENSILE STRENGTH	Very Good
SCUFF RESISTANCE	Very Good
ABRASION RESISTANCE	Very Good
ALKALI RESISTANCE	Very Good
ACID RESISTANCE	Very Good
OIL RESISTANCE	Very Good
HARDNESS	As high as 80 (Shore-A)
% FILM FORMING	100%
VISCOSITY	3,000 to 4,000 cps.
COST PER 0.001" THICKNESS	App. $.37 sq. yd.
FIRE HAZARD	None

Member Vinyl Dispersion Division, SPI

REYNOLDS CHEMICAL PRODUCTS COMPANY

ANN ARBOR, MICHIGAN

DIVISION OF STUBNITZ GREENE CORP.

For more information, circle No. 559

News OF INDUSTRY

nominated for the presidency of the American Society of Heating and Air Conditioning Engineers.

Bernard B. Daien has been appointed chief engineer, Transistor Devices, Inc.

R. Emerson Lynn, Jr. has been named manager of chemical engineering research at B. F. Goodrich Research Center.

Dr. Ottilie Amminger has been appointed chief metallurgist at Leschen Wire Rope Div., H. K. Porter Co., Inc. She will be responsible for quality control and the new metallurgical laboratory.

Arthur W. Ruff, Jr. has joined the metal physics section of the Metallurgy Div., National Bureau of Standards. He will study the behavior of imperfections in pure metals.

H. M. Webber has been appointed manager of process engineering for Harper Electric Furnace Corp.

Werner G. Holzbock has been named chief engineer, Askania Regulator Co.

Julian A. Terpenning has been named product manager, Foundry Resins, Archer-Daniels-Midland Co.

Dr. Edgar C. Bain, assistant executive vice president—operations, U. S. Steel Corp., has retired after 30 years of service. Dr. Bain began his career as head of the metallurgical laboratory.

Arthur F. Hubbard, chief engineer, Herman Nelson Div., American Air Filter Co., has been named chairman of the Technical Advisory Committee on Sound and Vibration Control, American Society of Heating and Air Conditioning Engineers.

Stephen E. Platz has been appointed assistant chief metallurgist, Duraloy Co.

Gilbert L. Olson has been named chief metallurgist, Trent Tube Co. **H. D. Kurtz** has been promoted to assistant chief metallurgist, the position formerly held by Mr. Olson.

Francis T. Greenup has been appointed chief product engineer, Consolidated Electrodynamics Corp.

(News of Companies on p 242)

Full House!

...a setko self-locking set screw **for every problem!**

... And, every Setko Self-Locking set screw is an *ace* performer! Each one depends on a specific design principle to lock fast.

They provide positive locking action ... speed assembly and cut costs by utilizing standard driving techniques ... don't require special tapping. All are available in regular points, patented Nu-Cup point, and standard sizes and threads. With the Setko System, they can be hopper-fed in sizes as small as #2 (.086" x ⅛").

ZIP-GRIP® SET SCREWS
Exclusive Contra-Thrust action locks at any point. Solves problems of loosening due to wear, clearance in the thread, or vibration. Can be re-used.

OFFSET SET SCREWS
When driven, two offset edges in threaded portion exert powerful spring pressure. Not affected by extreme variations in tapped holes.

CREST-LOK SET SCREWS
New, original design doesn't require precise tapping. Can be re-used repeatedly. Amount of lock can be altered by changing tap drill size.

POINT-LOK SET SCREWS
This design ends top-screw loosening on two-screw applications. Lower screw can be locked with Point-Lok without disturbing original setting. Can be re-used.

SPRED-LOK® SET SCREWS
This design is for soft metal applications. Top is "spread" slightly to take up "flow" of soft metal. Can be re-used.

Other Setko Self-Locking set screws that solve specific problems include Flush-Lok, Wedge, Truncated and Jam-Lok. A complete description of Setko set screws including Nu-Cup and Self-Tapping, and the Setko System for hopper-feeding headless set screws is contained in Catalog 21. Write today for your free copy

Set Screw & Mfg. Co.

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For more information, circle No. 443

Save Time, Maintenance and Money In Your Metal-Melting . . .

Specify Norton Refractory Cements

FOR FERROUS METAL-MELTING

type of equipment	metals melted	use of cement	Norton cement recommended			how applied
			number	maturing temperature		
indirect arc	alloy iron and steels	lining	RA 1307	1150°C	2100°F	rammed
		patching	RA 1307 RA 1162	1150°C 1000°C	2100°F 1850°F	rammed rammed
direct arc	alloy steel and malleable iron	troweling around electrodes	RA 1162	1000°C	1850°F	trowled
		lining roof and around electrodes	RA 1307	1150°C	2100°F	rammed
high frequency induction	stainless steel and refractory alloys	lining	RM 1170	1150°C	2100°F	rammed (dry)
		patching large furnaces	RM 1152	1200°C	2200°F	rammed
		patching small furnaces	RM 1992	1100°C	2000°F	troweled or rammed
ladles	iron and steel	lining	RA 1307	1150°C	2100°F	rammed

FOR NONFERROUS METAL-MELTING

low frequency induction	Al, Te, Si bronzes	lining	RM 1140	1250°C	2300°F	rammed
	general purposes	lining	RA 1307	1150°C	2100°F	rammed
indirect arc	brasses and bronzes	lining and patching	RA 1307	1150°C	2100°F	rammed
crucible melting furnaces ■	brasses and bronzes	lining and patching	RC 1188	1100°C	2000°F	rammed
reverberatory furnaces ▲	brasses and bronzes	lining and patching	RC 1188	1100°C	2000°F	rammed

■ Cement not in contact with metal; used in combustion chamber. ▲ Cement in contact with metal.

Norton ALUNDUM* fused alumina (RA), CRYSTOLON* silicon carbide (RC) and MAGNORITE* fused magnesia (RM) cements are stable and very refractory. Carefully blended to assure proper grain size distribution, they are excellent for the widest range of operations.

For complete facts as to the nature and selection of these *engineered and prescribed* Norton Rx's, contact your Norton Representative. He'll supply you with the booklet *Norton Refractory Cements*. Or write for your free copy to NORTON COMPANY, Refractories Division, 353 Pleasant Street, Worcester 6, Mass.

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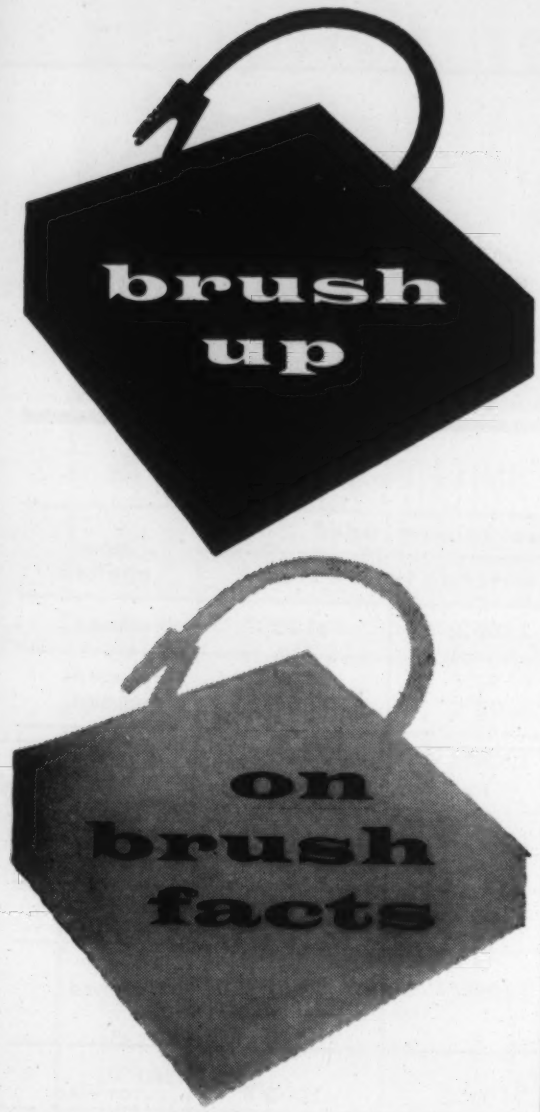

Choosing the carbon brushes that are supremely suited to your requirements is easy when you have the book that tells you all about brush characteristics and applications. Covering brushes for every type of fractional horsepower, automotive, aviation and industrial application, it represents 50 years of carbon and brush leadership. Its title? "Brushes by Speer."

The coupon below will bring you your copy with our compliments.

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St. Marys, Pa.

☐ Please send "Brushes by Speer."

☐ Please send information on carbon for use in_____

Name_____

Title_____

Address_____

City_____ State_____

For more information, circle No. 436

News of Industry

Companies

Temco Aircraft Corp. is transferring its scattered engineering groups to a new centralized engineering center at Garland, Texas. By January, 1958, approximately 3000 employees will be integrated at the Garland facility, including headquarters, engineering and present manufacturing personnel.

Formica Corp., an American Cyanamid subsidiary, has completed construction of a $1½ million plant addition that provides a 10-fold increase in floor space for resin manufacture.

Trionics Corp. has established a laboratory in Madison, Wis. for research and development services on a contract basis.

Techalloy Co., Inc. plans to be in full production at its new 24,000-sq-ft plant by December.

Timken Roller Bearing Co. has started construction of a new million dollar engineering building.

Union Carbide Corp. is now the official name of **Union Carbide and Carbon Corp.** Division name changes are: Carbide and Carbon Chemicals Co. to **Union Carbide Chemicals Co.**; and Linde Air Products Co. to **Linde Co.**

Trane Co. has completed construction of its technical engineering center adjacent to its research and testing laboratory.

United States Rubber Co. is spending a million dollars for expansion of nylon tire fabric production facilities at its Scottsville, Va. plant.

Atlantic Steel Castings Co. has announced a quarter-million-dollar building and equipment modernization program aimed at increasing production of high grade steels and parts.

Hewitt-Robins, Inc. announces that it will move to a new building to be constructed in the Melrose Park Industrial Center, Chicago.

United States Gasket Co., Div. of Garlock Packing Co., is now operat-

TUBING

STRAIGHT... PREFORMED OR COAXITUBE

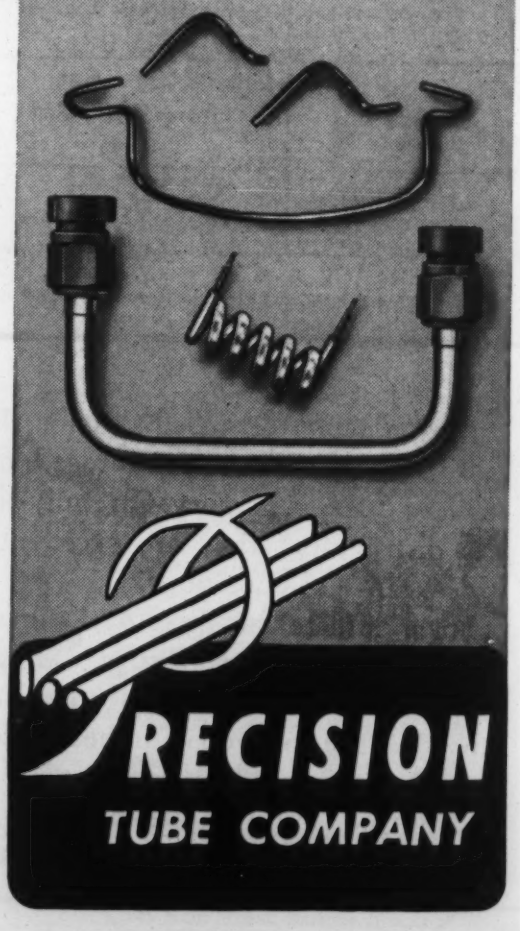
FROM .010" TO 1.000" TO YOUR SPECIFICATIONS

Whatever you need in tubing to any size, shape or alloy . . . Precision can supply it with precision accuracy, extra quality and at no extra cost.

Oxygen free copper and copper alloy tubing, nickel and nickel alloys, aluminum alloys, stainless steel—tubing for all electronic applications. Formed to exact specifications, single or double flared ends, complete with Standard A N Fittings.

Precision Coaxitube—A semi-rigid coaxial pair of conductors, sub-miniature sizes—low as .050" diameter, polyethylene or teflon dielectrics. Excellent mechanical properties, efficient shielding, low noise level for communication networks and missiles guidance systems — protected from false signals.

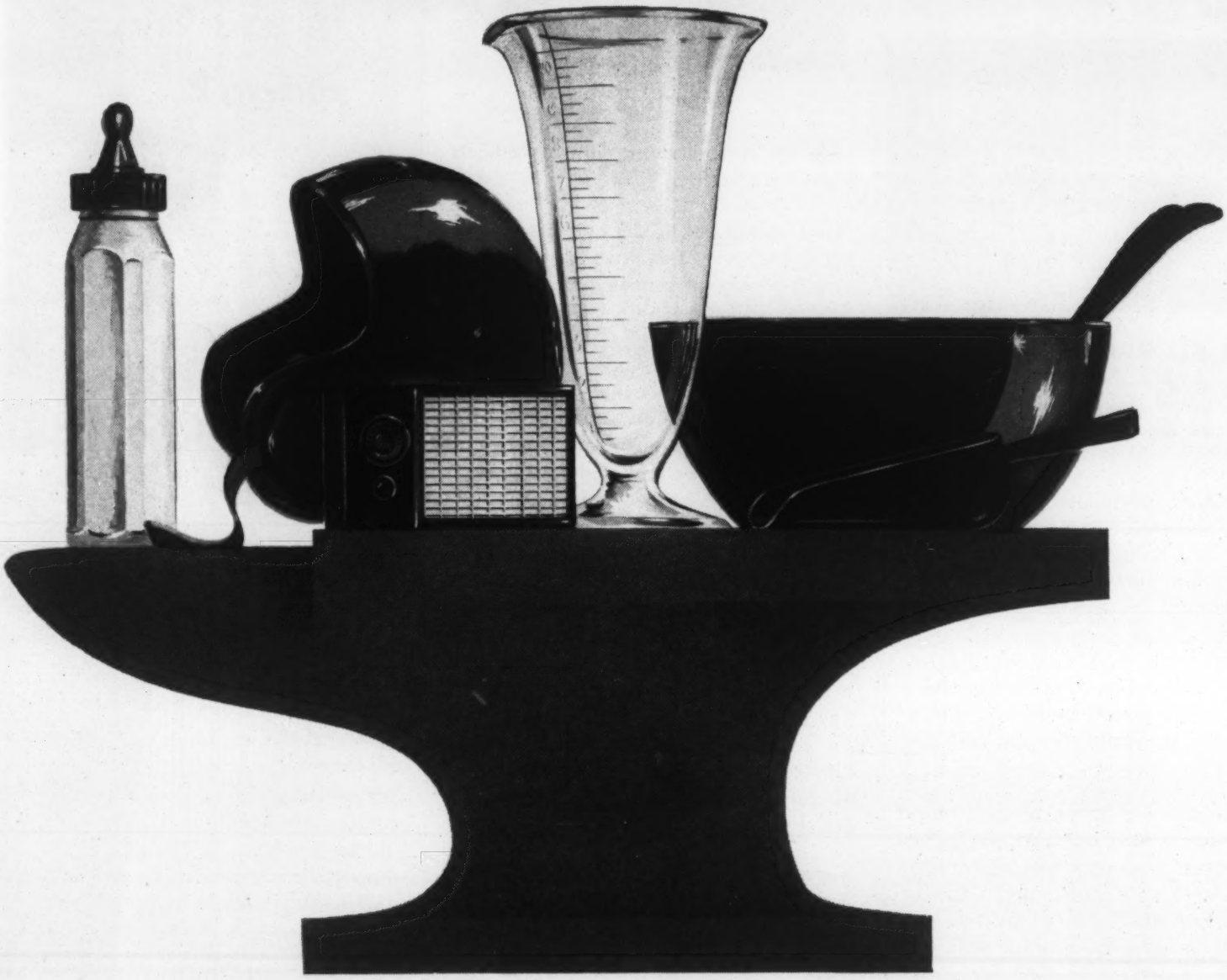
Let Precision's engineers help you improve your product and reduce manufacturing costs with preformed tubing, assemblies and Coaxitube. Write for folder and full details to Precision Tube Company, Inc., Dept. 4, North Wales, Pa.



PRECISION TUBE COMPANY

For more information, circle No. 501

For sturdy plastics . . .



switch to high strength

GREX*

GREX, new high density polyethylene, offers a combination of vastly improved properties that broadens sales potential for plastic fabricators and their customers as well.

For example, GREX brings to industrial moldings impact and tensile strength far superior to many costlier molding materials. GREX-made hospital items that require sterilization and chemical cleaning, won't wilt, stay like new. In refrigerator containers and trays, GREX stays brittle-free, demonstrating resistance to extreme cold. GREX makes top-grade electrical insulation. Film made from GREX features good 'slip' and is suitable for high speed packaging. It is easily heat sealed and is an effective moisture barrier.

Toughness, durability, boilability—learn how these and other improved properties of GREX can help *you* turn out better made, faster selling plastics! Mail the coupon today!

*TRADEMARK FOR W. R. GRACE & CO.'S POLYOLEFINS

W. R. GRACE & CO.
POLYMER CHEMICALS DIVISION

Offices Clifton, N. J. — Plant Baton Rouge, La.

W. R. GRACE & CO., POLYMER CHEMICALS DIVISION, DEPT. 93
225 Allwood Road, Clifton, New Jersey

Please send more information about new GREX plastic.

I am interested in these uses: .....

.....

NAME.....TITLE.....

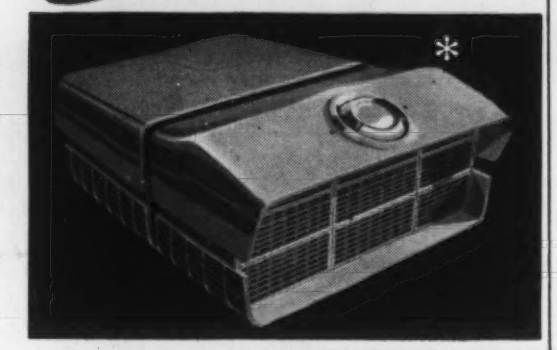
COMPANY.....

ADDRESS.....

CITY.....STATE.....

For more information, turn to Reader Service card, circle No. 485

Idea!

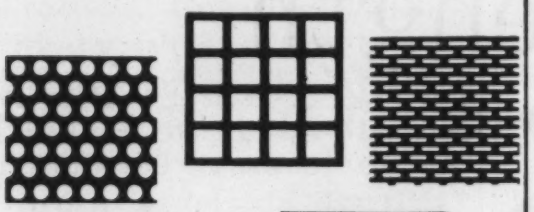


room air conditioning unit using H & K perforated metals

In the ¾ ton window air conditioner illustrated, perforated metals have been combined successfully with injection moulded plastics. The utilization, here, of new louvered perforated metals in adjustable frames on the frounced surface in combination with new embossed patterns on sides and under surfaces, afford rich tactile qualities hitherto unattainable in the air conditioner field.

Harrington & King perforated metals provide the Industrial Designer and other men of ideas unlimited opportunities to offer both functional and aesthetic properties as demanded in products for today's market. Contact H & K for your perforating requirements.

*Product Development by William M. Schmidt Associates



A few of the thousands of H & K perforated patterns. Illustrations are reduced in size.

Fill in and mail coupon to nearest H & K office.

THE **Harrington & King** PERFORATING CO. INC.

Chicago Office and Warehouse
5671 Fillmore Street
Chicago 44, Ill.

New York Office and Warehouse
112 Liberty Street
New York, N.Y.

Please send me—

☐ GENERAL CATALOG NO. 62
☐ STOCK LIST of Perforated Steel Sheets

NAME_____
TITLE_____
COMPANY_____
STREET_____
CITY_____ ZONE_____ STATE_____

For more information, circle No. 470

News of Industry

ing its new nylon-teflon extrusion plant in Camden, N. J.

Air Reduction Co., Inc. has expanded its laboratory facilities in order to develop polymers used primarily for paints, adhesives, plastics and coatings.

Milton Roy Co. has purchased **Anders-Lykens Co.**, manufacturers of instrument air dryers and gas dehydrators. The new acquisition will be operated as the Anders Div. of Milton Roy Co.

Link-Belt Co. has started construction of a new $5 million bearing plant in Indianapolis. The plant is planned for completion this year and is expected to be in full production by 1959.

Philtrol Seals, Inc. is the new name of **Superior Hermetic Seals Co.**, a division of Phillips Control Corp.

Narmco, Inc. is constructing a new three-unit laboratory scheduled for completion by December. This is Narmco's first step toward a planned million dollar industrial research and development center.

Kelsey-Hayes Co. has purchased **Control Specialists, Inc.** and will operate the engineering and research firm as a division.

Napco Industries has purchased **Detroit Bevel Gear Co.**, a subsidiary of Gear Grinding Machine Co.

U. S. Drill Head Co. has completed the first phase of its three-quarter-million dollar expansion program.

Societies

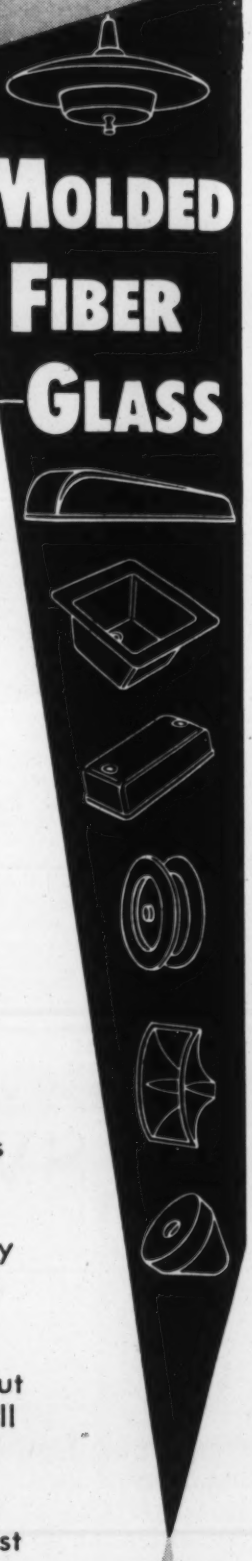
Plastic Bottle and Tube Manufacturers is the name of a new division of the Society of the Plastics Industry, Inc. Officers of the new division are: chairman—John Jennings, Continental Can Co., Inc.; vice chairman—George E. Pickering, Lamex Chemical Corp.; secretary and treasurer—Henry E. Griffith, Bradley Container Corp.

Objectives of the new division are: 1) to develop and maintain industry standards and nomenclature; 2) to

New product in the "think" stage?

time to think about

MOLDED FIBER GLASS



. . . stronger pound for pound than steel . . . rust and corrosion resistant . . . unaffected by weather . . . lightweight . . . dielectric . . . beautiful . . . custom molded in matched metal dies for uniformity and dimensional accuracy.

If you are not familiar with the many advantages of MOLDED FIBER GLASS, as custom molded by the Molded Fiber Glass Company, you are invited to write us, without obligation, for full information.

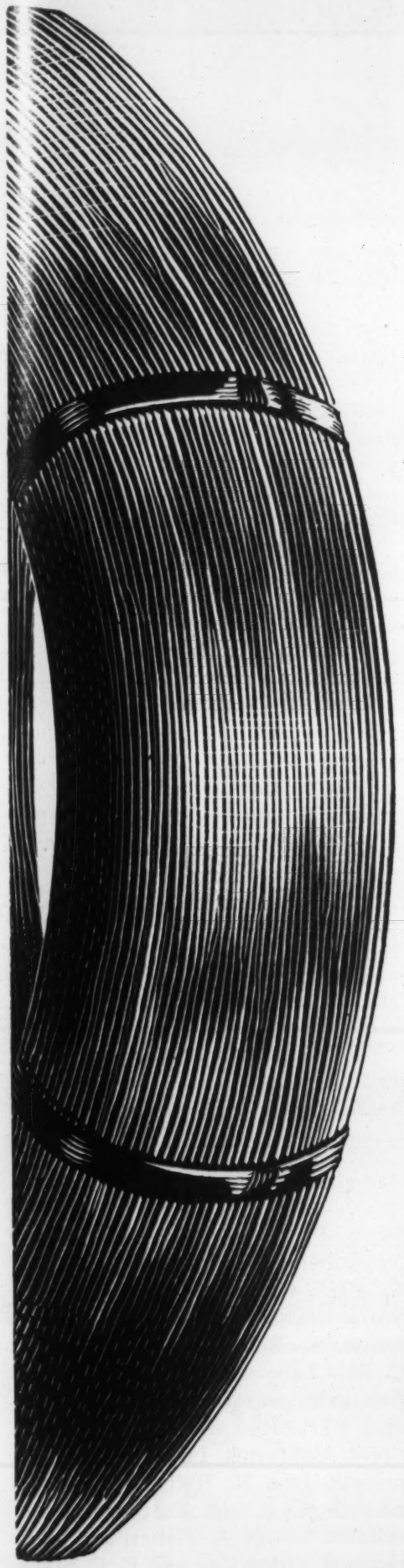
MOLDED FIBER GLASS may be just what your new product needs.

Molded Fiber Glass Company

THE GREATEST NAME "MOLDED FIBER GLASS" IN REINFORCED PLASTICS

4421 Benefit Avenue
Ashtabula, Ohio

For more information, circle No. 492



209 DIFFERENT KINDS OF WIRE

. . . *and Youngstown Makes Them All*

No matter what type wire you require, Youngstown should be your specification for high quality, uniformity and dependability. That's because they are **all** drawn from specially refined open-hearth carbon steels to meet **your** most exacting specifications.

Every grade of Youngstown Wire is rigidly quality-controlled in all steps of its production from ore mining to finish drawing and coating. This guarantees you a uniform product—both chemically and physically—that's free from injurious seams and piping, laps, die marks, as well as internal tearing and cupping.

Why not study this listing—it may suggest new products you could make from Youngstown Wire to boost both your sales volume and profits.

For additional information or metallurgical assistance, write or phone today to your nearest Youngstown District Sales Office.

QUALITY · YOUNGSTOWN · SERVICE

THE YOUNGSTOWN SHEET AND TUBE COMPANY

Manufacturers of Carbon, Alloy and Yoloy Steel

General Offices - Youngstown 1, Ohio

District Sales Offices in Principal Cities

Aircraft Wire
Alloy Wire
Annealed Wires
Armor Wire:
Armoring Wire
Artificial Flower Wire
Automotive Wire
Awl Wire
Axle Wire
Bail Wire
Bale Tie Wire
Baling Wire
Ball Pin Wire
Basic Wire
Basket Handle Wire
Bed Rods
Bessemer Spring Wire
Bicycle Chain Stud Stock
Bicycle Spoke Wire
Binding Wire
Bolt and Rivet Wire
Bond Wire
Bonnet Wire
Bookbinder Wire
Border Wire
Bottle Handle Wire
Bottling Wire
Box Binding Wire
Box Hinge Wire
Brace Wire
Brick Cutting Wire
Bright Wire
Broom Wire
Brush Wire
Buckle Wire
Bundling Wire
Button Hook Wire
Cable Armor Wire
Can Key Wire
Cap Screw Wire
Car Heater Wire
Car Seat Wire
Card Wire
Cast Steel Wire
Ceiling Hook Wire
Chain Welding Wire
Chain Wire
Chair Rods
Chair Wire
Channel Bead Wire
Channel Pin Wire
Check Rower Wire
Clasp Wire
Clip Wire
Clothes Line Wire
Clothes Pin Wire
Coat Hanger Wire
Coat and Hat Hook Wire
Coiled Spring Wire
Cold Heading Wire
Concrete Reinforcement Wire
Copper Bearing Wire
Coppered Wire
Core Wire (A.C.S.R.)
Cork Screw Wire
Cotter Pin Wire
Crimping Wire
Croquet Arch Wire
Curry Comb Wire
Curtain Rods
Damper Rods
Double Clinch Wire
Dowel Wire
Duck Bill Nail Wire
Eave Trough Hanger Wire
Edge Wire
Elevator Hoisting Cable Wire
Fence Wire
Ferrule Wire
Fine size Wire
Firing Pin Wire
Fish and Leader Wire
Flesh Fork Wire
Flexible Shaft Wire
Florist Wire
Foundry Core Wire
Frame Wire
Fruit Jar Wire
Fuse Wire
Galvanized Wire
Galvanized Armor Cable Wire
Galvanized Brace Wire
Garment Hanger Wire
Gate Hook Wire
Grape Tie Wire
Grass Catcher Wire
Guard Wire
Gun Wrapping Wire
Hairpin Wire
Handle Wire
Harness Snap Wire
Hat and Coat Hook Wire
Hat Rods
Head Lining Wire
High Carbon Wire
Hog Ring Wire
Hook and Eye Wire
Hoop Wire
Hose Binding Wire
Husking Pin Wire
Key Wire
Key Ring Wire
Key Stock
Keystone Wire
Lacing Wire
Lantern Wire
Lathing Wire
Link Wire
Lintel Wire
Lock Washer
Loop Wire
Machinery Wire
Machine Screw Stock
Manufacturers' Wire
Market Wire
Mat Border Rods
Mat Wire
Mattress Wire
Metal Stitching Wire
Muzzle Wire
Nail Head Wire
Nail Wire
Neck Wire
Neck Yoke Ring Wire
Netting Wire
Nickel Steel Wire
Non-corrosive Wire
Nut Cracker Wire
No-Sag Spring Wire
Oval Wire
Oven Rack Wire
Pail Bail Wire
Pail Rim Wire
Piano Rods
Pin Wire
Pinion Wire
Pivot Wire
Pipe Winding Wire
Plow Steel Wire
Plunger Wire
Pneumatic Tire Bead Wire
Pot Chain Wire
Poultry Netting Wire
Pump Chain Wire
Rake Tooth Wire
Refrigerator Shelf Wire
Reinforcement Wire
Riveting Wire
Rivet Rods
Rivet Wire
Rock Fastener Wire
Roll Threading Wire
Rope Wire
Saddle Spring Wire
Sash Cord Wire
Scrapless Nut Wire
Scratch Brush Wire
Screen Wire
Screw Wire
Screw Driver Wire
Screw Rod Wire
Shade Roller Wire
Shelf Wire
Skid Chain Wire
Smooth Wire
Snare Wire
Soft Processed Wire
Spark Plug Wire
Spiral Hooping
Spoke Wire
Spring Wire
Stapling Wire
Stitching Wire
Stone Wire
Stove Bolt Wire
Stove Pipe Wire
Stove Rods
Straightened & Cut Wire
Strapping Wire
Stud Stock
Surveyors' Chain Wire
Tack Wire
Tag Wire
Tie Wire
Tire Bead Wire
Towel Rods
Toy Wire
Trap Spring Wire
Transom Rods
Trellis Wire
Tuning Pin Wire
Tying Wire
Umbrella Wire
Wash Boiler Wire
Weaving Wire
Welding Wire
Whip Guard Wire
Wood Screw Wire
Wrapping Wire
Zig Zag Spring Wire

For more information, turn to Reader Service card, circle No. 442

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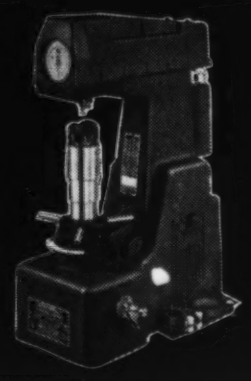
WILSON "ROCKWELL"—
THE WORLD'S STANDARD OF HARDNESS TESTING ACCURACY

WILSON "ROCKWELL"
HARDNESS TESTERS



When it's WILSON "ROCKWELL"-TESTED *you KNOW it's RIGHT!*

Easy to operate—all controls at hand. *Takes rough* service—maintains accuracy after years of operation.

Expert Wilson Service—helps you choose proper model... keeps it at work. A staff of WILSON hardness testing experts is available to provide quick emergency service if it is ever needed.

The booklets listed below give complete and helpful data on the indicated WILSON equipment.

DH-325 for "Rockwell" Regular
DH-326 for "Rockwell" Superficial
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ACCO **WILSON**
MECHANICAL INSTRUMENT DIVISION
AMERICAN CHAIN & CABLE
230-E Park Avenue, New York 17, N. Y.

A FULL WILSON LINE TO MEET EVERY HARDNESS TESTING REQUIREMENT

FULLY AUTOMATIC
SEMI-AUTOMATIC
REGULAR
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SUPERFICIAL
MICRO & MACRO HARDNESS TESTERS

Write for one or all of these booklets
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YOU NOW HAVE IT!

At your fingertips . . . new uses, properties and sources of engineering materials

Just issued to all MATERIALS IN DESIGN ENGINEERING subscribers . . . a library of data compiled by M/DE's editors. No other annual reference issue offers you so much up-to-date selection data on so many engineering materials.

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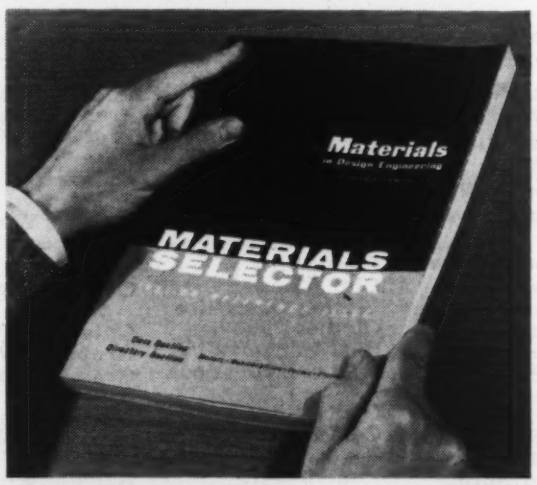
Effects of radiation
Fabricating properties
Joining
Available forms
Suggested uses
Design factors



3 Lists names and addresses of over 2,700 suppliers.

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A Reinhold Publication,
430 Park Avenue, New York 22, N. Y.

News OF INDUSTRY

develop statistical data; and 3) to disseminate information.

Steel Founders' Society of America announces the following major winners of its 3rd Product Development Contest: Joe Jopling, project engineer, Phil H. Edwards Co., $1000 and gold certificate for his paper, "Composite Weld Construction for Rock Ripper Frame;" Russel W. Henke, Russ W. Henke Associates, $750 and silver certificate for "Analytical Design Leads to Replacement of Weldments with Steel Castings in Compaction Heavyweight;" Donald N. Rosenblatt, chief metallurgist, American Foundry and Machine Co., $1000 and gold certificate for "Use of Steel Castings in Mining Equipment;" and American Steel Foundries, $750 and silver certificate for "Wearpact Dipper Points for Power Shovel."

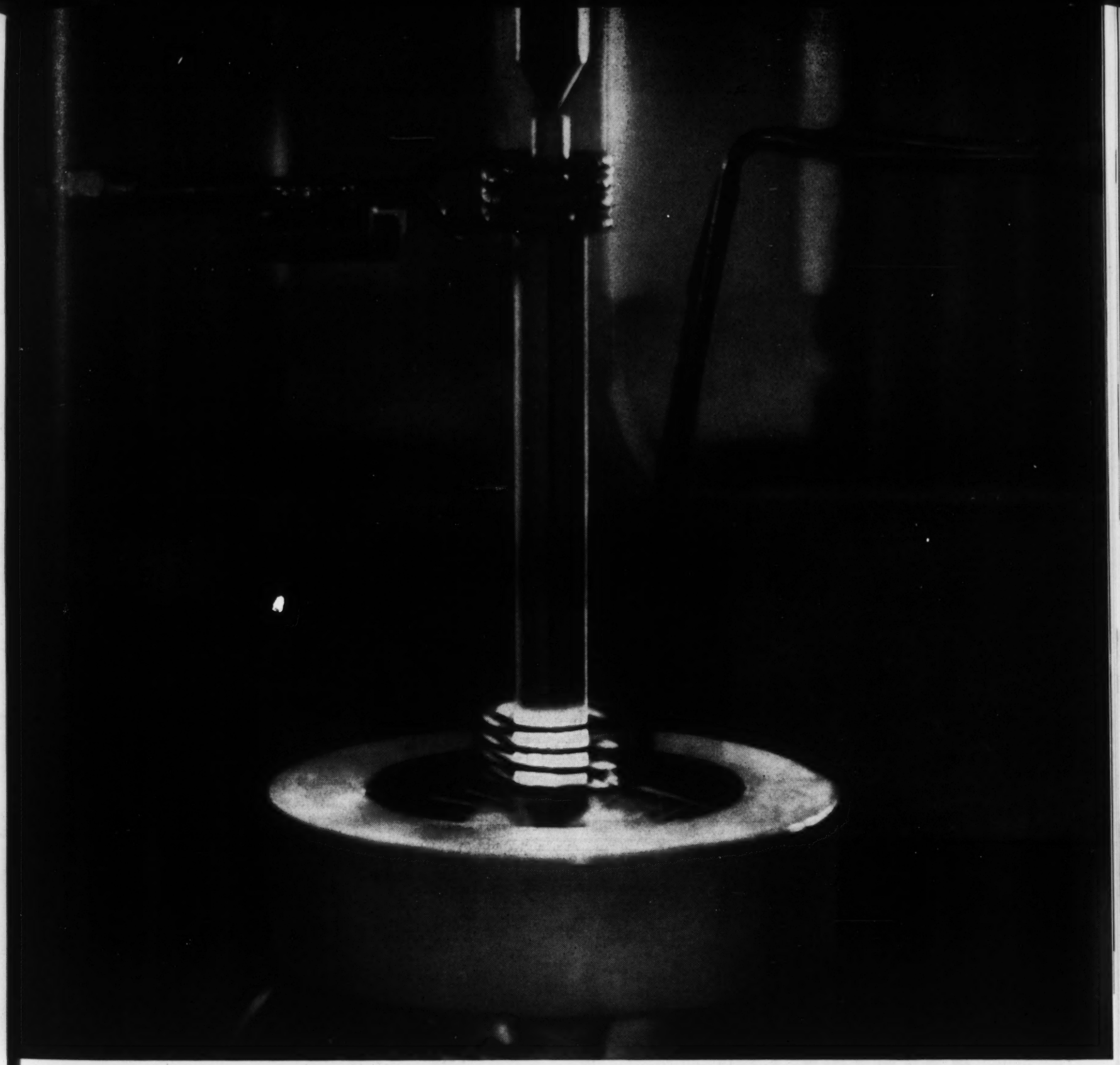
Metals Engineering Institute, a division of **American Society for Metals** announces that Ted DuMond, former editor of MATERIALS & METHODS, has joined the Cleveland headquarters' staff as editor-in-chief of the Institute's educational courses. Mr. DuMond will also be secretary of the ASM special engineering program committee.

American Society for Metals announces the following 1957-1958 national officers: president — G. MacDonald Young, Aluminum Co. of America; vice president—Clarence H. Lorig, Battelle Memorial Institute; treasurer—Robert H. Aborn, Edgar C. Bain Laboratory for Fundamental Research; secretary—W. H. Eisenman. Trustees are: Dr. Donald S. Clark, California Institute of Technology; John H. Hollomon, General Electric Co.; Carl E. Swartz, consultant; George A. Fisher, Jr., International Nickel Co.; and E. E. Stansbury, University of Tennessee.

American Standards Assn. announces the following two recipients of the highest awards in the field of voluntary standards: Roger E. Gay, the Howard Coonley Medal for "great service in advancing the national economy through voluntary standards;" and John Robert Townsend, the Standards Medal for leadership in the actual development and application of standards.

(News of Meetings on p 248)

For more information, circle No. 427



Ketos shaft being induction hardened to Rockwell 55-56, while ends remain soft for final machining. Photographed at Control Instrument Co., Inc., Brooklyn, N. Y.

KETOS has wide hardening range with minimum volume change...

Ketos is a low priced alloy tool steel that can be hardened from low temperatures with practically no volume change. It has deep hardening qualities, and a fine grained structure, that make it desirable for many production parts.

That's why nondeforming Ketos is well suited not only for most tool steel applications such as gauges, dies, and taps but also for close-tolerance, wear-resistant parts like the actuator bar shown in the induction heating unit above. The thin contact edges of this particular part withstood a "life test" of over 4-million high speed blows. No other steel tested lasted more than 1-million cycles before it chipped and failed.

If Ketos sounds like the steel you should be using, call your nearby Crucible warehouse. Stocks of Ketos and dozens of other special tool steels are large, delivery fast. *Crucible Steel Company of America, The Oliver Building, Mellon Square, Pittsburgh 22, Pa.*

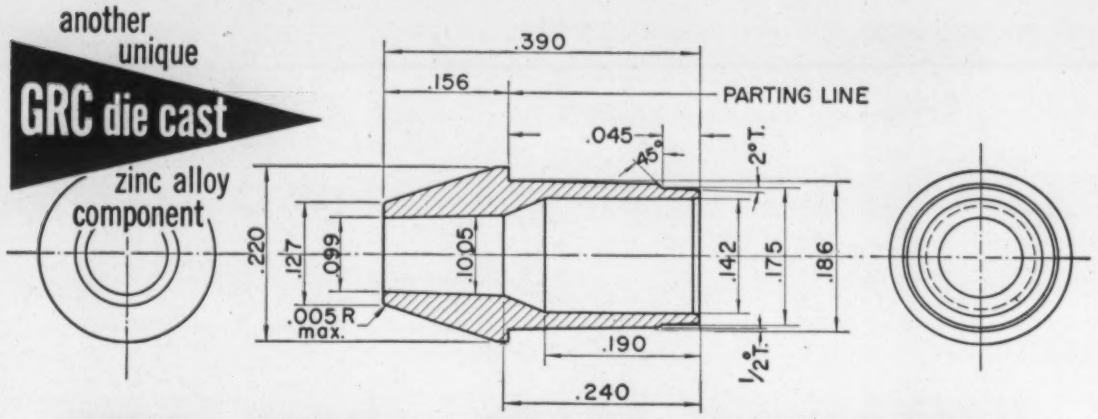
CRUCIBLE first name in special purpose steels

Crucible Steel Company of America

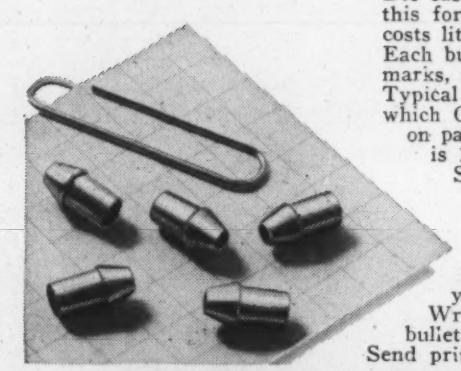
Canadian Distributor — Railway & Power Engineering Corp., Ltd.

For more information, turn to Reader Service card, circle No. 538

another unique GRC die cast zinc alloy component



GRC CUTS TINY BUSHING COST TO $2.00/M



Die cast by GRC in zinc alloy in a single automatic operation, this former screw machine part for a ball point pen, now costs little more than $2.00 per thousand in lots of a million. Each bushing is uniform, clean and accurate—no cut-off marks, no burrs, no secondary trimming and no scrap loss. Typical of the production economies and wide design latitude which GRC's exclusive patented methods have made possible on parts "no bigger than your thumbnail.." (Maximum size is 1¾" long, ½ oz.; no size too small).

Simple or complex, let GRC's unique techniques go to work for you . . . on tiny die cast *and plastic molded* parts made to order . . . on their wide variety of standard parts available in stock—wing and round head thumb nuts and screws, cap nuts, rivets, gears and pinions—you'll be glad you did.

Write, wire, phone TODAY for bulletins, spec sheets and prices. Send prints or specs for quotation.

GRIES

GRIES REPRODUCER CORP.

World's Foremost Producer of Small Die Castings

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FOAM YOUR OWN

URETHANE PRODUCTS ON PRODUCTION BASIS WITH THE NEW NEWTON

Molded parts, spraying, void filling . . . the Newton machine does all by correctly metering catalyst and resin, intimately mixing and delivering them at rate of 2 to 12 lbs. per minute. Handles rigid or flexible prepolymers, quasi or one shot systems—permits continuous on-off operation without excessive maintenance. Teflon® plug valve is self-lubricating . . . no need to dismantle and clean head after each cycle.

The Newton machine is your answer to urethane products on a production basis

MANUFACTURED BY NEWTON TOOL & MANUFACTURING COMPANY, SOLD ONLY THRU ISOCYANATE PRODUCTS INC.

ISOCYANATE PRODUCTS, INC.

WILMINGTON 99, DELAWARE

For more information, turn to Reader Service card, circle No. 549

News OF INDUSTRY

Meetings

AMERICAN INSTITUTE OF MINING, METALLURGICAL AND PETROLEUM ENGINEERS, INC., 15th annual electric furnace conference. Pittsburgh. Dec 4-6.

SOCIETY OF THE PLASTICS INDUSTRY, INC., eighth Film, Sheeting and Coated Fabrics Div. conference. New York City. Dec 10-11.

SOCIETY OF AUTOMOTIVE ENGINEERS, INC., annual meeting. Detroit. Jan. 13-17.

AMERICAN INSTITUTE OF ELECTRICAL ENGINEERS, winter general meeting. New York City. Jan 20-24.

AMERICAN SOCIETY OF HEATING AND AIR CONDITIONING ENGINEERS, 64th annual meeting. Pittsburgh. Jan 27-29.

SOCIETY OF PLASTICS ENGINEERS, 14th annual national technical conference. Detroit. Jan 28-31.

AMERICAN SOCIETY FOR TESTING MATERIALS, committee week. St. Louis. Feb 9-15.

AMERICAN INSTITUTE OF MINING, METALLURGICAL AND PETROLEUM ENGINEERS, INC., annual meeting. New York City. Feb 16-20.

AMERICAN ROCKET SOCIETY and AMERICAN SOCIETY OF MECHANICAL ENGINEERS, joint aviation conference. Dallas, Tex. Mar 17-20.

STEEL FOUNDERS' SOCIETY OF AMERICA, annual meeting. Chicago. Mar 17-18.

NATIONAL ASSN. OF CORROSION ENGINEERS, annual conference. San Francisco. Mar 17-21.

DESIGN ENGINEERING SHOW. International Amphitheatre, Chicago. Apr 14-17.

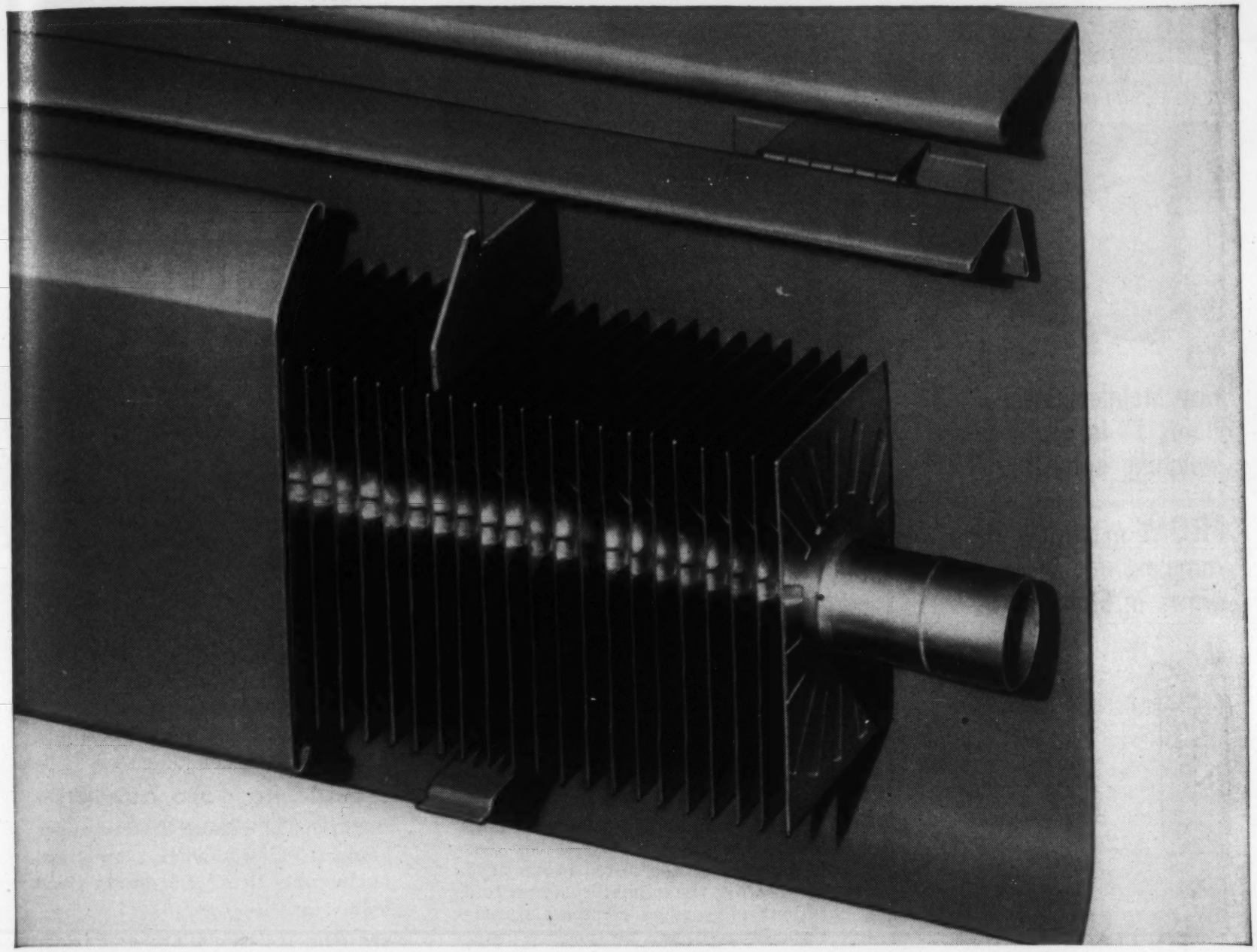
AMERICAN WELDING SOCIETY, welding show. St. Louis. Apr 14-18.

ELECTROCHEMICAL SOCIETY, spring meeting. New York City. Apr 27-May 1.

AMERICAN ELECTROPLATERS' SOCIETY, annual convention. Cincinnati, Ohio. May 19-22.

AMERICAN SOCIETY FOR TESTING MATERIALS, 61st annual meeting and apparatus exhibit. Boston. June 22-28.

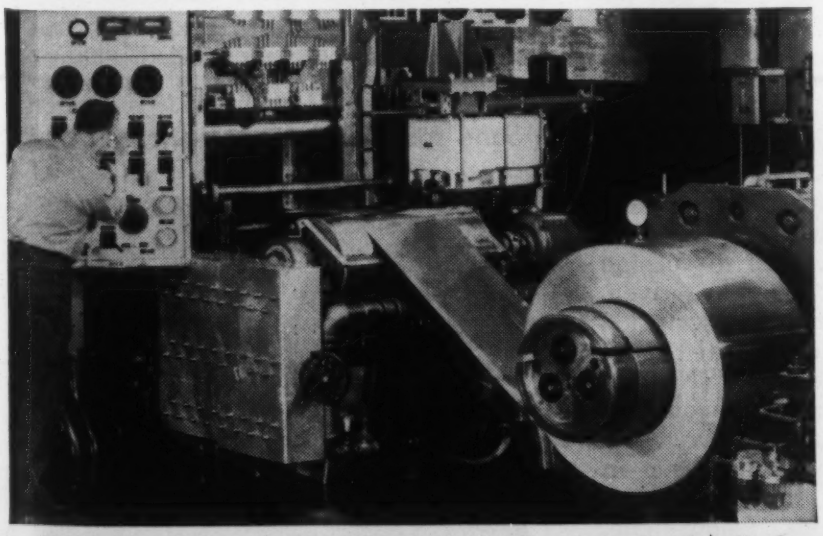
AMERICAN INSTITUTE OF ELECTRICAL ENGINEERS, summer general meeting. Buffalo. June 23-27.



A section of Rittling 750 baseboard radiation. Rittling uses Anaconda Aluminum Alloy 3003-H14, .025 gage in 4'' and 4⅜'' widths for fins.

"From past experience, we know we can count on American Brass for quality Aluminum Coiled Sheet."

The Rittling Corp., Buffalo, N. Y., manufacturer of baseboard and fin tube radiation for commercial, residential, and institutional applications has used Anaconda Copper Tube in their units for many years. Now they are using Anaconda Aluminum Coiled Sheet for the fins. "We can always count on The American Brass Company for a quality product," says Mr. Dan Moran, purchasing agent.



Rittling stamps the fins from large coils of aluminum sheet. Copper tubes are expanded into flanged holes in the fins to provide a tight, large-area contact for efficient heat transfer.

ALUMINUM COILED SHEET produced to the high standards of quality and uniformity maintained by The American Brass Company is now available for prompt shipment from our Torrington Division to all points in the United States.

It is rolled on the most modern, high-speed equipment, X-ray controlled to close tolerance in gage. High-speed, electronically operated slitters give exact widths with clean edges on evenly and tightly wound coils. Latest type annealing furnaces—with controlled atmosphere and temperature—provide high uniformity of metal structure to meet specified mechanical-property limits.

FOR IMMEDIATE ACTION, contact The American Brass Company's District Sales Office nearest you or The American Brass Company, Torrington Division, Torrington, Conn. 5798

Available for prompt shipment to all points in the U. S.

Anaconda Aluminum Coiled Sheet in gages from 0.006'' to 0.064'' and in widths from ⅜'' to 28''; coils up to 100 pounds per inch of width, in alloys: 1100, 3003, 3004, 5005, 5050, 5052.

ANACONDA®

ALUMINUM COILED SHEET

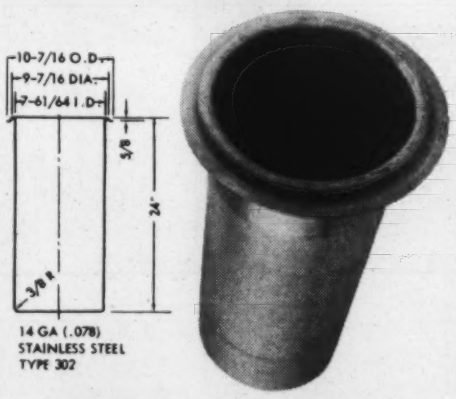
Made by The American Brass Company

For more information, turn to Reader Service card, circle No. 530

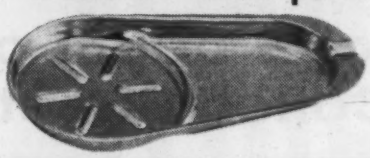
FROM 17,000 Gallon refrigerated Stainless Steel Tanks

TO tiny Stainless Steel floats 1" in diam. weighing only 1 oz.

FROM extremely deep, complex, one piece draws in Stainless



TO high production draws for small parts



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BOOKS & REPORTS

Books

Concise Guide to Plastics. *Herbert R. Simonds. Reinhold Publishing Corp., New York, 1957. Cloth, 6 by 9 in., 329 pp. Price $6.95*

Without going too deeply into details about any one subject this book attempts to give readers a useful understanding of plastics materials as a whole. The book's function is essentially that of a guide to both the newcomer and the veteran in plastics materials. It gives properties, forms, prices and applications of all known American commercial plastics, including those still in the laboratory stage. The book also helps the design engineer select the plastics material best suited to his needs by showing the capabilities and limitations of various commercial plastics. In addition, the book contains a list of the 43 most important plastics producers with their addresses, names of chief officers, products, trade names, and descriptions of operations.

Herbert R. Simonds is the author of *Industrial Plastics*, and co-author of *Handbook of Plastics* and *Extrusion of Plastics, Rubber and Metals.*

Chemistry of Natural and Synthetic Rubbers. *Harry L. Fisher. Reinhold Publishing Corp., New York, 1957. Cloth, 6 by 9 in., 214 pp. Price $6.50*

This book, described by the author as a "book of facts," delves into the vulcanization, acceleration. anti-oxidation and anti-ozonation of natural, synthetic, reclaimed and hard rubber. A brief history of the development of natural and synthetic elastomers and a general discussion of the chemistry of rubber are given. Included is an illustrated description of the new "synthetic natural rubber hydrocarbons," Ameripol SN and Coral rubber. The book also contains information on the chemistry and properties of raw materials used in making synthetic rubbers, such as butadiene, styrene, isobutylene, chlorostyrene and vinylpyridine.

Dr. Fisher, a recipient of the Charles Goodyear Medal (ACS) in 1949, is a former director of the

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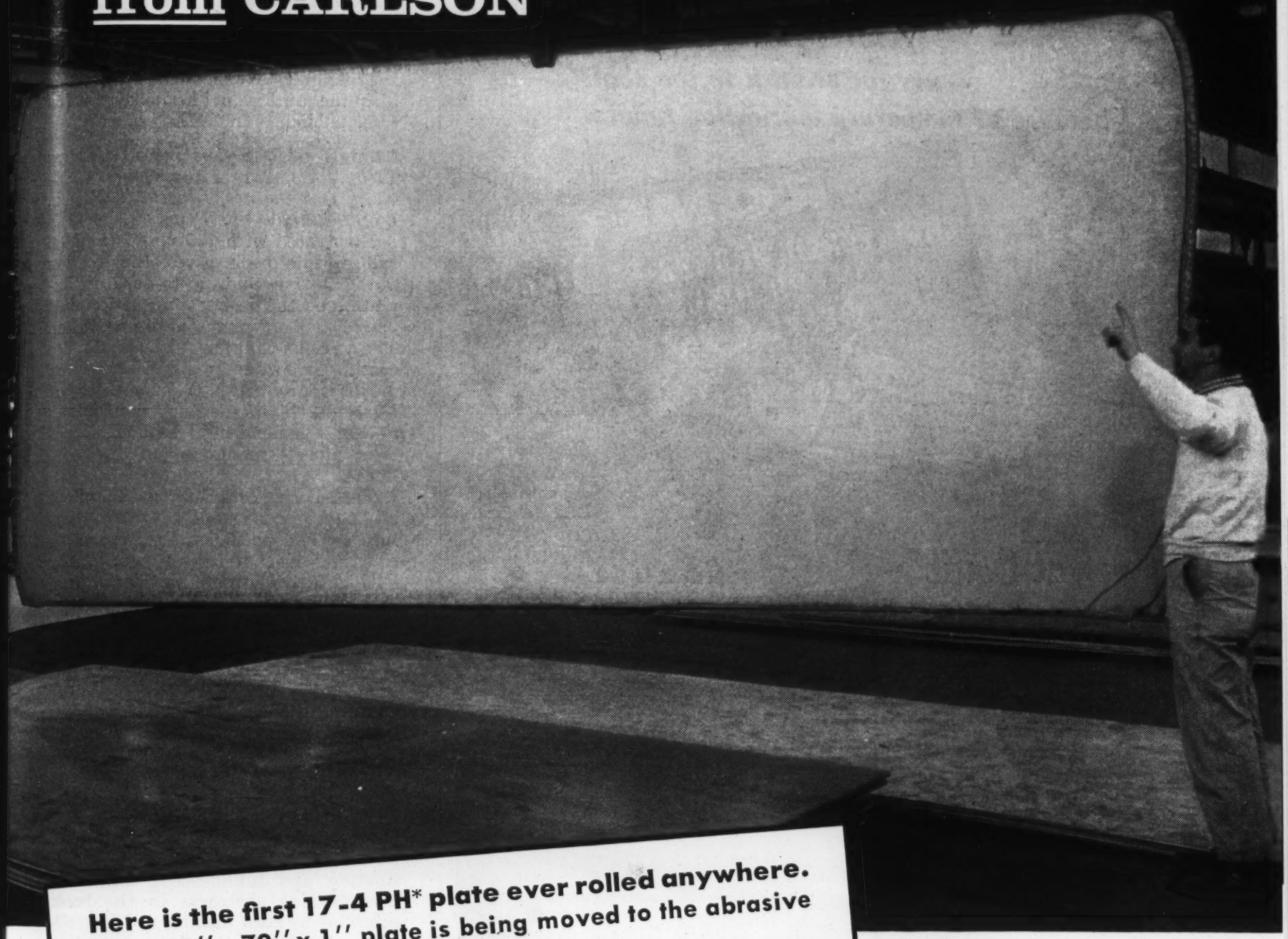

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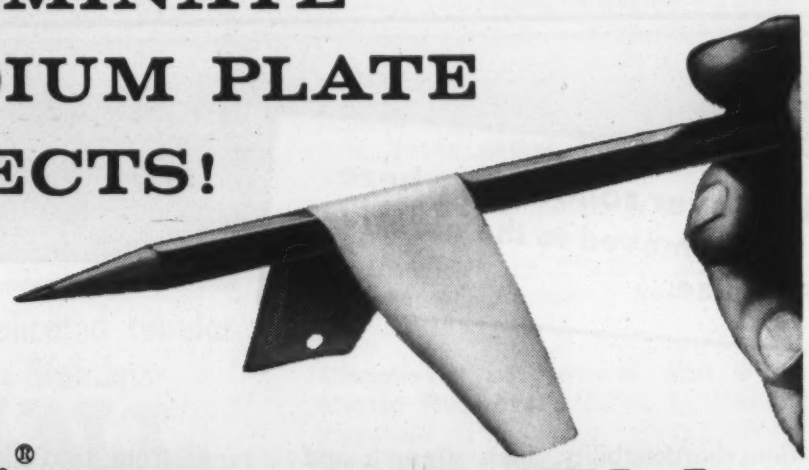

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BOOKS & REPORTS

Los Angeles Rubber Group. He is also the author of *Rubber and Its Use*, published in 1941.

Design of Die Castings. *Gustav Lieby. American Foundrymen's Society, Des Plaines, Ill., 1957. Paper, 6 by 9 in., 206 pp. Price $8*

Illustrated with 135 photos and 16 tables, this book gives the reader authoritative and up-to-date information on the design, production and use of nonferrous metal die castings. The various chapters discuss: 1) die casting procedures; 2) features of die cast products; 3) properties of low and high melting nonferrous alloys; 4) die design and construction; and 5) machining of die castings.

The book contains a complete bibliography, as well as tables listing ASTM specifications, composition and mechanical properties for lead, zinc, tin, aluminum, magnesium and copper-base alloys. The present volume is a translation of an original German version first published in 1949.

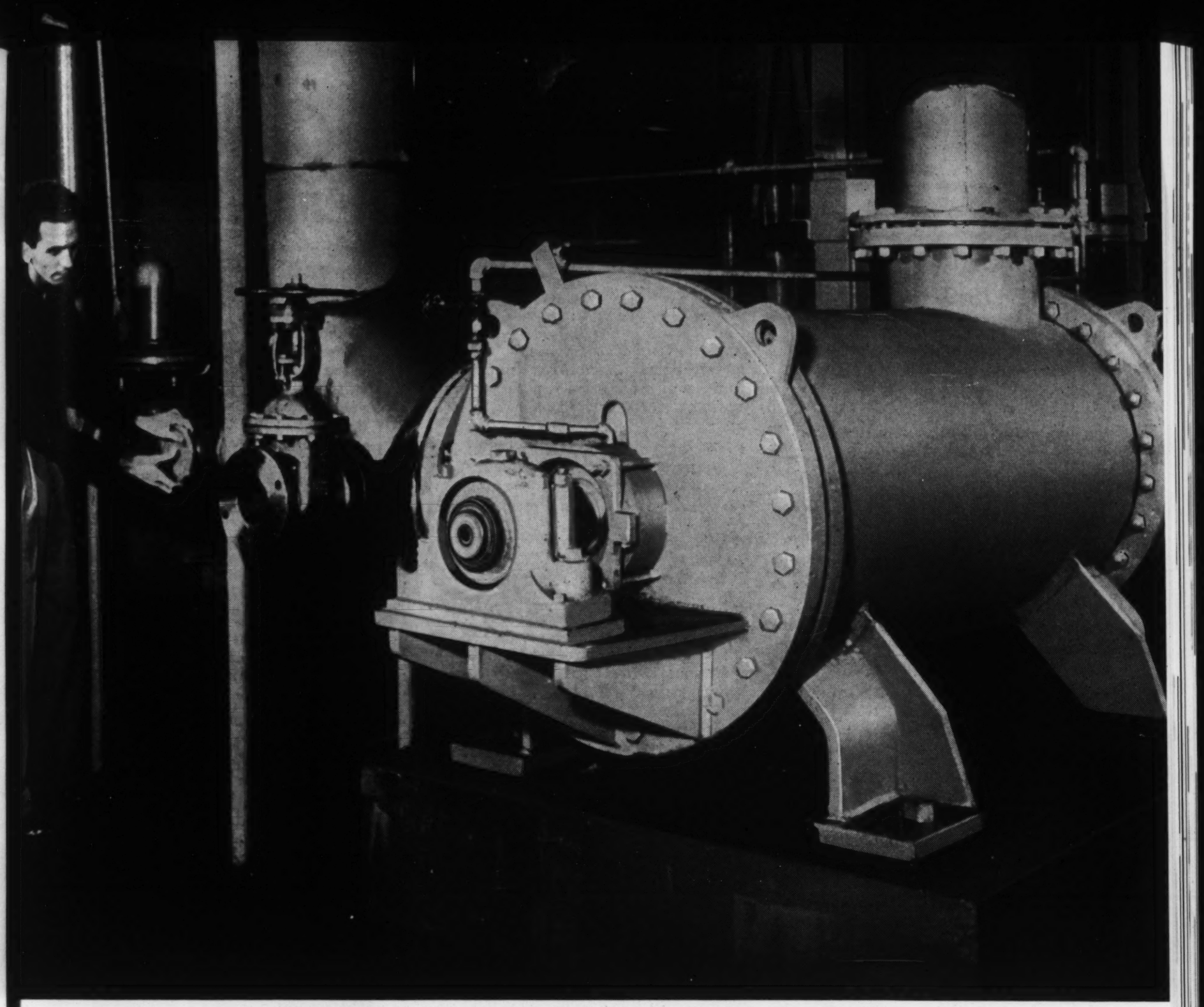
Semiconductor Abstracts: Volume 3. *Edited by E. Paskell. John Wiley & Sons, Inc., New York, 1957. Cloth, 8½ by 11½ in., 330 pp. Price $10*

With this book it is possible to obtain three full years of organized abstracts of literature on semiconducting and luminescent materials. The various abstracts in the book, compiled by staff members of Battelle Memorial Institute, give properties, applications and other pertinent data on such semiconducting and luminescent materials as germanium; silicon; carbon; selenium; indium, selenium, aluminum, cesium and gallium, antimonide; cadmium sulphide; copper oxide and sodium and potassium halide. The book contains both an author and a subject index.

Reports

Properties of titanium THE EFFECTS OF INTERSTITIAL CONTAMINANTS ON THE NOTCH-TENSILE PROPERTIES OF TITANIUM AND TITANIUM ALLOYS. *Part 2: Alloy Titanium. E. P. Klier and N. J. Feola, Univ. of Syracuse. Aug '56. 202 pp. Available from Office of Technical Services, Dept. of Commerce, Wash. 25, D. C. Price $5.50 (PB 121575)*

Tensile and notch-tensile properties of six titanium alloys contami-



Chlorine dioxide mixer in service at the Carolina Division of Riegel Paper Corp. The unit was manufactured by Improved Machinery Inc. It is lined with ⅛" Rem-Cru A-70 titanium sheet.

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BOOKS & REPORTS

nated with carbon, oxygen and nitrogen are given for temperatures ranging from 75 to –320 F. Effects of testing temperature, alloy content, metallurgical structure, contamination level and strain rate on promoting notch sensitivity are discussed.

Fire retardant coatings FIRE RETARDANT COATINGS. *S. Collis, Wright Air Development Center. Aug '54. 62 pp. Available from Office of Technical Services, Dept. of Commerce, Wash. 25, D. C. Price $1.75 (PB 131002)*

Evaluates fire retardant coatings for aircraft surfaces. The desired coating should have sufficient insulation against flame temperatures of 2000 F to hold temperatures of the base metal to 350 F. No entirely satisfactory coating was found. Boric acid, borax and other low temperature glass forming materials appear promising, especially for use in top coats.

Leaded steels LITERATURE SURVEY ON LEADED STEELS. *R. C. Elliott and D. M. Koffman, Watertown Arsenal Laboratory. July '55. 38 pp. Available from Office of Technical Services, Dept. of Commerce, Wash. 25, D.C. Price $1 (PB 111917)*

An evaluation of published information on the manufacture, fabrication and properties of leaded steels shows that machining costs can be cut considerably by use of these materials. The report outlines the history and technological aspects of leaded steel, including fabrication, production, properties, machinability and applications.

Glass-reinforced plastics EVALUATION OF GLASS FABRIC REINFORCED PLASTIC LAMINATES. *F. R. Barnet, U. S. Naval Ordnance Laboratory. Jan '53. 37 pp. Available from Library of Congress, Photoduplication Service, Publications Board Project, Wash. 25, D. C. Price $6.30 (PB 124842)*

Evaluates the effect of fabric weave, yarn weight, fabric finish, resin type, resin content, and temperature on the physical, electrical and mechanical properties of glass cloth plastics laminates.

Iron alloys DEVELOPMENT OF CAST IRON-BASE ALLOYS OF AUSTENITIC TYPE FOR HIGH HEAT-RESISTANCE AND SCALE-RESISTANCE. *F. Eberle, J. H. Hoke and W. E. Leyda, Babcock and Wilcox Research Center. Jan '57. 99 pp. Available from Office*

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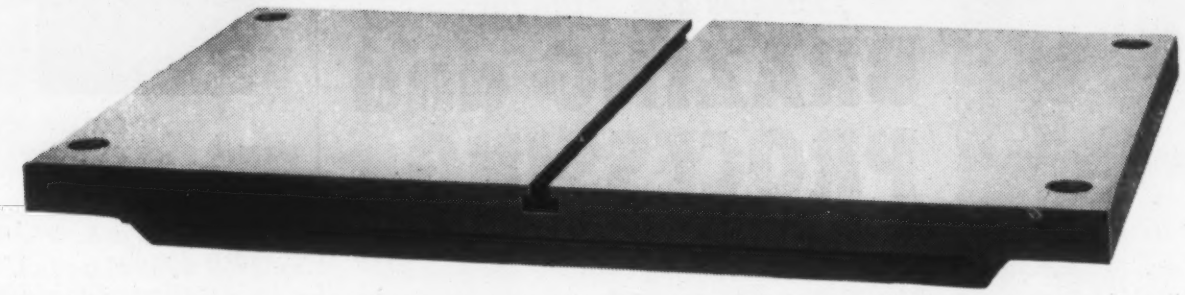

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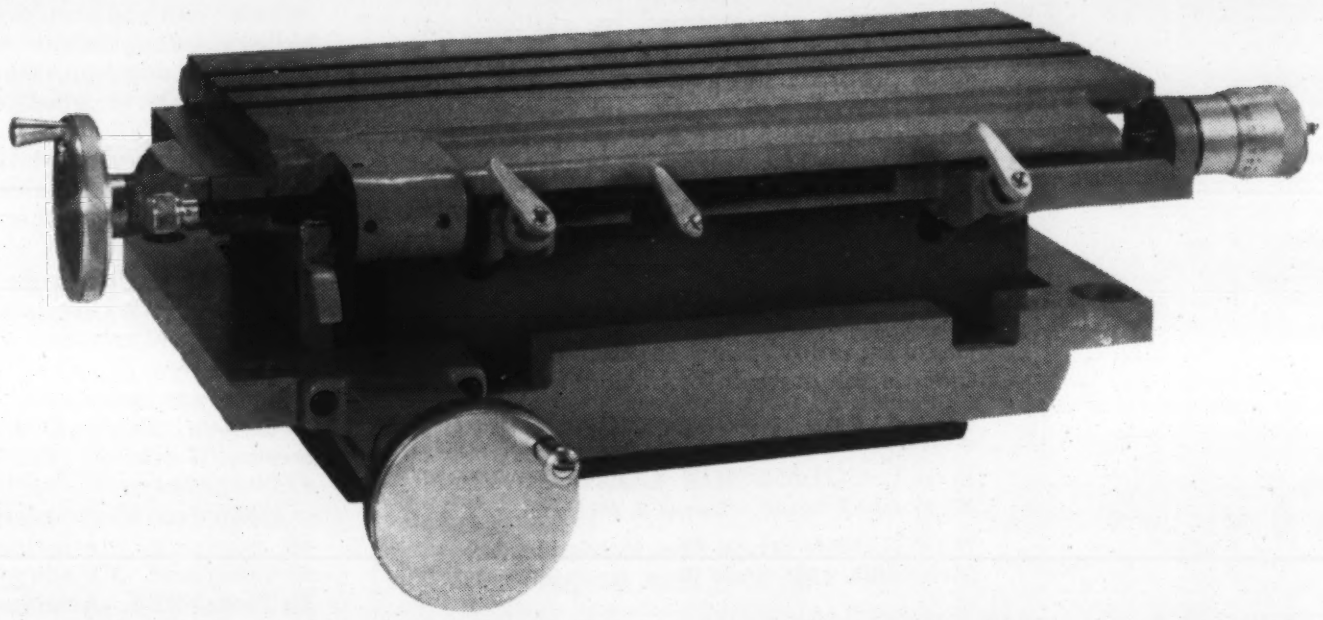

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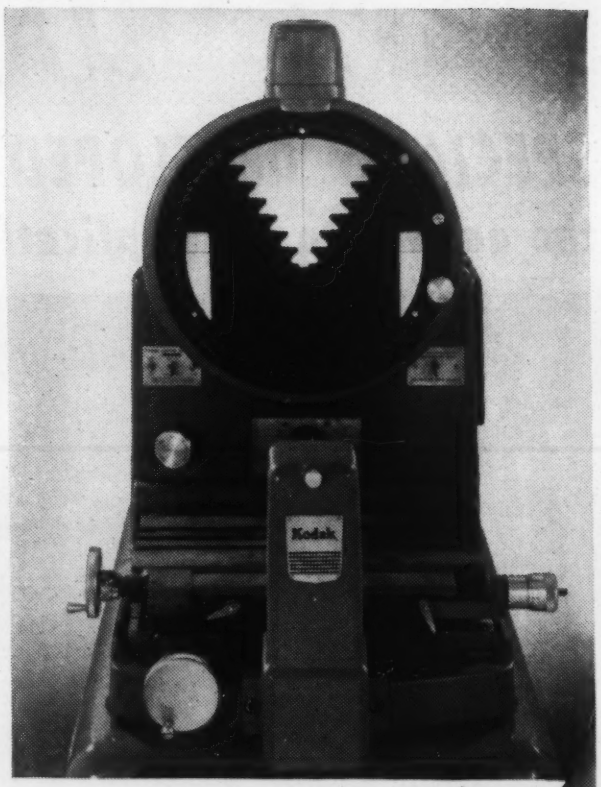

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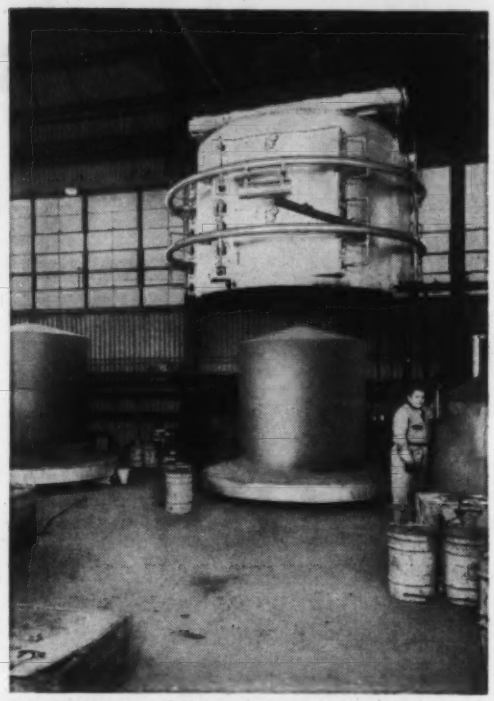
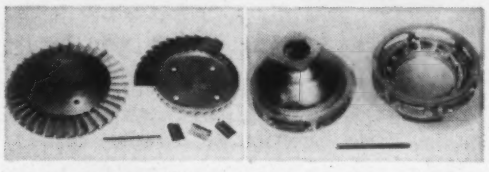


The 72-inch dia. hydrogen atmosphere furnace being lowered over a loaded furnace bell. Detroit plant.



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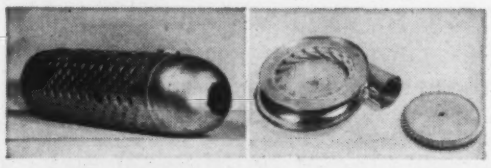

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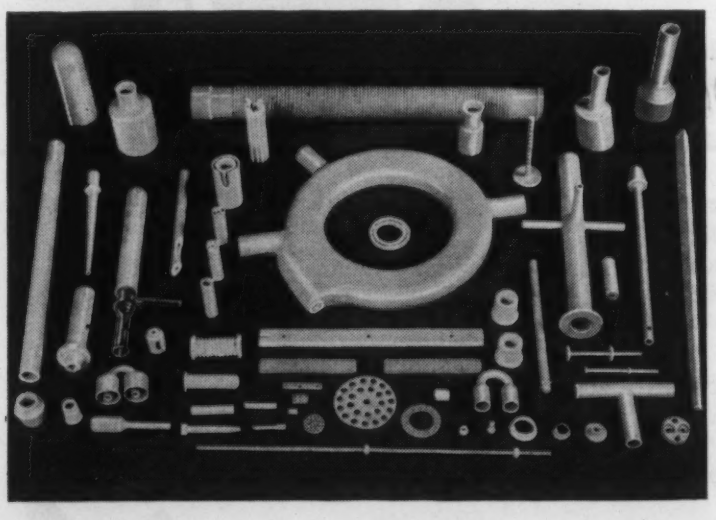

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BOOKS & REPORTS

of Technical Services, Dept. of Commerce, Wash. 25, D. C. Price $2.50 (PB 121950)

Outlines the development of iron-base alloys having a minimum iron content of 45, minimum carbon of 0.50, minimum chromium of 20, and nickel between 27 and 32%, part of which can be replaced by cobalt. Alloys strengthened with 5% additions of tantalum, molybdenum and tungsten have good creep rupture strength at 1600 to 1800 F. The alloys have good oxidation resistance, but only fair hot tensile strength and resistance to thermal shock.

Protective coatings PREPARATION OF PROTECTIVE COATINGS BY ELECTROPHORETIC METHODS. *A. C. Werner et al, Vitro Corp. of America. Apr '57. 53 pp. Available from Office of Technical Services, Dept. of Commerce, Wash. 25, D. C. Price $1.50 (PB 131062)*

Describes electrophoretic methods of applying protective coatings to molybdenum. Multilayer coatings of 80 nickel-20% chromium and nickel-bonded chromium carbide provide good static air oxidation resistance to molybdenum in an oxidizing atmosphere at 1800 to 2000 F. All panels fail under severe thermal shock.

Rhenium INVESTIGATIONS OF RHENIUM. *C. T. Sims et al, Battelle Memorial Inst. Sept '56. 86 pp. Available from Office of Technical Services, Dept. of Commerce, Wash. 25, D. C. Price $2.25 (PB 121653)*

Information on the physical, mechanical and electrical properties of rhenium metal. Describes a new method for preparing high purity rhenium powder by reduction of a hydrolyzed rhenium halide. Outlines a method for fabricating alloys with up to 2% rhenium. Describes some of the uses of the metal in electrical and electronic materials.

Corrosion of metals CORROSION OF METALS IN TROPICAL ENVIRONMENTS: PART I—TEST METHODS USED AND RESULTS OBTAINED FOR PURE METALS AND A STRUCTURAL STEEL. *A. L. Alexander et al, Naval Research Laboratory. June '57. 46 pp. Available from Office of Technical Services, Dept. of Commerce, Wash. 25, D. C. Price $1.25 (PB 121952)*

Reports and compares the corrosion rates and characteristics of aluminum, lead, nickel, zinc, copper and structural steel exposed for eight years to five tropical environments in the Panama Canal Zone.

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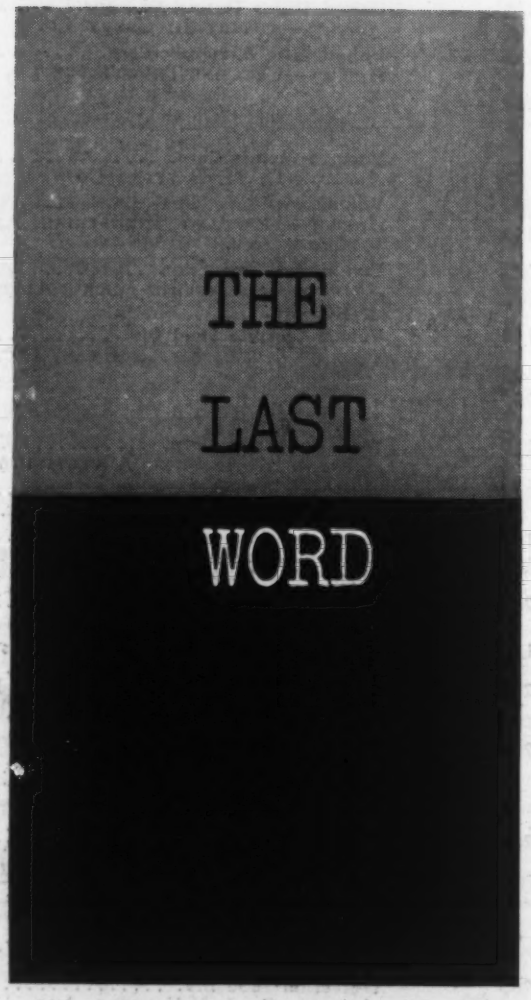


by ***H. R. Clauser,*** *Editor*

What the Russians Are Reading

The other week I received a post card from Siberia. It came from Prof. John Nielsen, head of the NYU metallurgical department, who was spending a few weeks in Russia. He said that he had seen copies of our magazine in several of the plants he had visited. I was surprised at this, since we have few if any subscriptions in Russia. But John went on to explain that the M/DE issues he saw were not originals but photo-offset copies. I suppose we should be angry at the Russians for infringing on our copyrights, but instead we are flattered that they should go to so much trouble to get copies of our magazine.

Sputnik and Bad Manners

Speaking of Russia, I think we copied some of Russia's bad manners when no public official (as far as I know) sent them a note of congratulations on their launching of the first earth satellite. Granted that there are serious weapons implications inherent in satellites. But the launching of the first one was a tremendous scientific and engineering achievement, and it was a legitimate part of the world-wide geophysical year program. Why not offer the Russians our congratulations on a job well done?

An Adventure Story

Earl R. Parker, of the University of California, predicts that within the next five years designers will have at their disposal ductile ceramics with strengths up to 500,000 psi and elongations of 10%. He made this prediction in his ASM Campbell Memorial Lecture last month at the Metal Show.

It was a fine lecture and presented a beautiful example of creative science. His subject was "Modern Concepts of Flow and Fracture." He told the fascinating story of the long search for answers to the questions of why metals flow and why they fracture. And he showed how the basic knowledge gained from this search is being applied to produce better engineering materials.

In commenting on the brittleness of ceramic materials, Dr. Parker made an observation that is applicable to all materials that we are seeking to improve. He said that it is not a weakness of ceramics as much as the weakness of man that perpetuates the brittleness in ceramics. So it is up to man to learn how to capture and retain in polycrystalline materials the ductility that exists in single crystals.

For Comfort Buy a Cab

Every now and then I receive letters from readers complaining of the poor design and durability of our present-day automobiles. I'm sure many others agree with them. I do. I would prefer less class and more utility in my automobile.

There now appears to be some hope for us old-fashioned people. Checker Cab Mfg. Co. will put on the market next spring a civilian version of the sturdy and functional Checker taxicab. If advance publicity is correct, the car will be built for comfort, convenience and durability. If you want one of the new Checker passenger cars, put in your order early. They expect to produce only 12,000 of them.

Materials for Bosoms

There is hardly a place where materials problems don't crop up sooner or later. According to *Time* magazine's report on a recent meeting of the American Society of Plastic and Reconstructive Surgery, plastic surgeons are seeking a sponge-like material that stays soft indefinitely. It seems that the present polyvinyl sponge (called Ivalon) which they now use in operations to build up bosoms has two disadvantages. It shrinks 20%. And it does not stay spongy, but in time becomes as hard as a baseball.

Another new development using

B.F.Goodrich Chemical *raw materials*

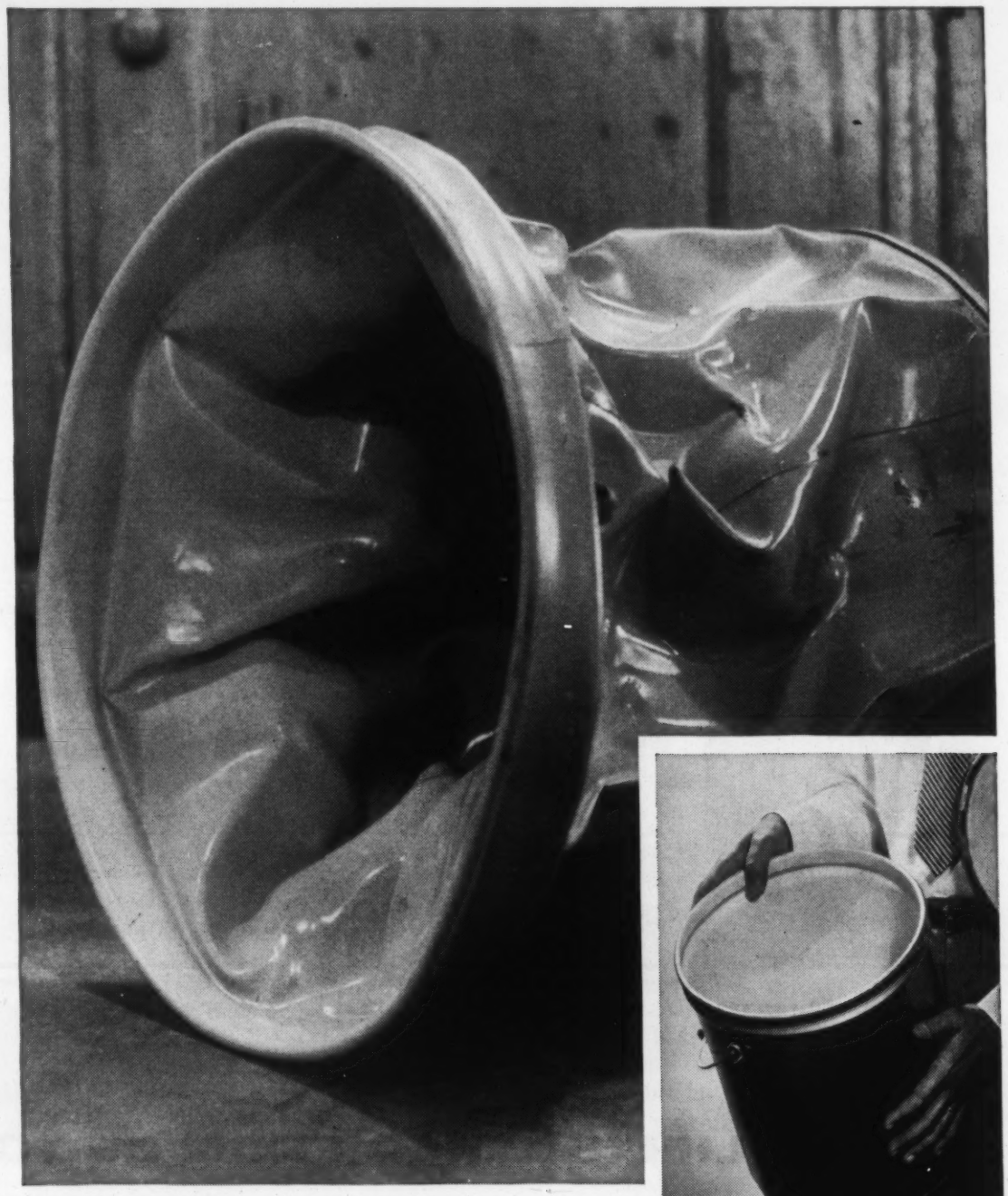
they

KO'd

the drum–

but not

the coating!



LOOK CLOSELY at this intentionally mangled steel drum. No cracks, flaking or peeling of the corrosion resistant coating—an organosol based on Geon polyvinyl resin.

Inland Steel Container Company offers this RDL-4 lining on drums and pails for handling highly corrosive liquids, bulk granulars and abrasive solids.

Linings made from Geon are remarkably resistant to abrasion, acids, alkalis and most chemicals. They are long-lasting, have excellent adhesion and high elasticity and are unaffected by temperature extremes or aging.

Geon-lined steel drums and pails have already been proved successful as shipping containers for many materials. Some of these include: corrosive chemicals, aqueous non-solvent solutions, water emulsions, detergents, disinfectants, 50% lactic acid, phosphoric acid, slurries and abrasive materials like titanium sponge and slips for pottery.

You can put versatile Geon resins and compounds to work for you in many ways. For more details, write Dept. GB-6, B.F.Goodrich Chemical Company, 3135 Euclid Avenue, Cleveland 15, Ohio. Cable address: Goodchemco. In Canada: Kitchener, Ontario.

Inland Steel Container Company, *Chicago, Ill. offers drums and pails with this lining in a range of sizes from 1 to 65 gallons.*

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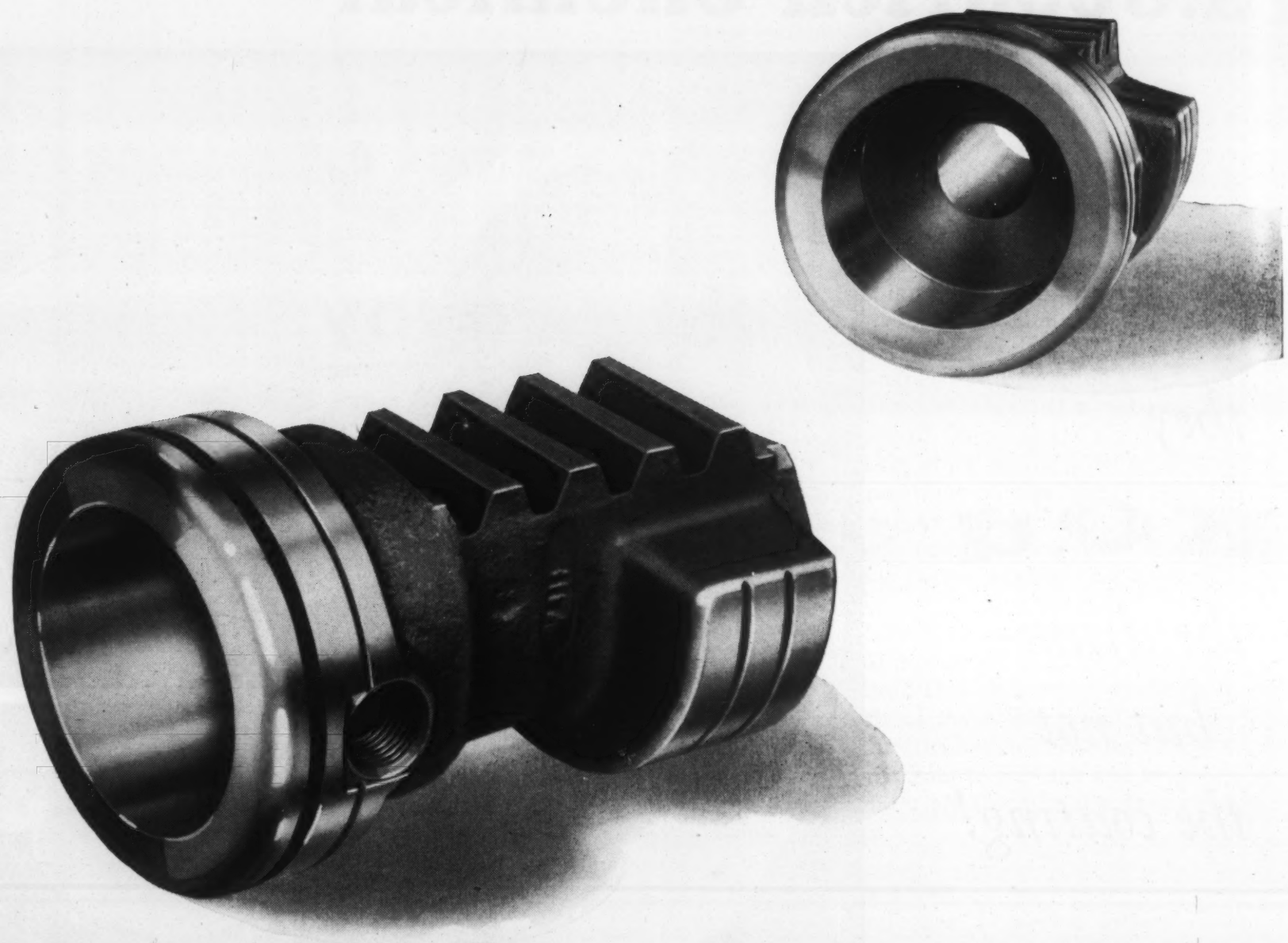


TOOL LIFE SOARED FROM 25 TO 750 PIECES

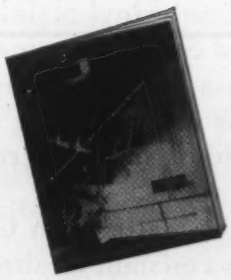
WITH ARISTOLOY LEADED

Counterboring 8 lb. forging was costly for large steering gear manufacturer

Excessive tool breakage was running into hundreds of dollars per month for a large automobile parts manufacturer. On 2.17″ ID counterboring operation of this forging made from A.I.S.I. 5120, chips were long and continuous. They wrapped around the tool, fouling it and causing premature tool failure. Tool life averaged only 25 pieces per tool.

A change to Leaded Aristoloy 5117 brought about an immediate improvement not only in tool life but in increased production and vastly improved finish. Tool life was upped to 750 pieces per tool. Spindle speed was increased from 113 to 239 R.P.M. and feed from .007 to .0134 I.P.R.

If you have a problem involving counterboring or deep hole drilling, call your nearest Copperweld district office. We will be glad to have a field metallurgist, experienced in application of lead treated steels, work with you.



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For more information, turn to Reader Service card, circle No. 391

It's not too late to enter M/DE's . . .

1957-58 Awards Competition

for the Best Use of Materials in Product Design

Enter any new product or redesigned product, assembly, subassembly or single part that shows sound, imaginative or progressive use of engineering materials.*

**Engineering materials: metals, nonmetallics, finishes and coatings, and materials forms (such as castings, forgings, moldings, etc.)*

16 CASH AWARDS

FIRST AWARD — **$500** and plaque

FIVE AWARDS OF MERIT — **$100 each** and certificate

TEN CITATIONS — **$50 each** and certificate

Rules of the Competition: A Brief Summary

(For more complete details, see the October issue, pp 145-8.)

1. Materials producers or suppliers are not eligible.

2. The entry must have been designed, redesigned or put into production during the calendar year of 1957.

3. Provide the following information:

a. A detailed description of the product, including photographs, drawings, before-and-after illustrations, etc.

b. A description of the service and/or fabrication requirements that must be met by the product or material(s).

c. A description of the material(s) previously used (if entry is a redesign).

d. A description of the material(s) selected for the entry.

e. An explanation of *how* and *why* the material(s) selected best met the design and service requirements or (if a redesign) resulted in improved performance and/or lower cost. Back up the selection of the material(s) with evidence—facts, data, charts and tables.

4. Entries or portions thereof will not be returned unless requested. Send copies, not originals, of valuable papers.

5. MATERIALS IN DESIGN ENGINEERING reserves the right to publish articles based on winning and non-winning entries. Payment for non-winning articles published will be at usual rates.

6. All entries must be postmarked not later than *January 15, 1958.*

TO SEND YOUR ENTRY:

Use a separate blank for each entry; additional entry blanks available on request. Attach entry blank below, or its equivalent, to your entry and mail to:

Awards Editor, Materials in Design Engineering, 430 Park Ave., N. Y. 22, N. Y.

NAME _____ TITLE _____

NAME(S) OF PERSON(S), GROUP OR ORGANIZATION WHO WOULD RECEIVE AWARD

_____

COMPANY _____

STREET ADDRESS _____ CITY _____ STATE _____

NAME OR BRIEF DESCRIPTION OF PRODUCT BEING ENTERED

_____

WAS DESIGN (OR REDESIGN) OF ENTRY EITHER COMPLETED OR PLACED IN PRODUCTION DURING 1957?

_____

Film of **TENITE POLYETHYLENE** helps "package" many items

Here's an ingenious use illustrating three properties of polyethylene that make it a valuable packaging material.

The young lady in the picture has solved the perennial vacation problem of how to keep household plants growing while the family's away. Her solution is to "package" them in bags or film made of Tenite Polyethylene.

The polyethylene, offering resistance to transmission of water vapor, insures that water will not escape. However, the polyethylene film is gas permeable, transmits oxygen and carbon dioxide, and permits the plant to "breathe." Finally, being transparent, the film lets the sunlight through.

Transparency, gas permeability and water resistance are important in many packaging applications. But Tenite Polyethylene offers still more advantages. It is heat sealable... chemically inert... doesn't puncture, tear or "run" easily... remains flexible at low temperatures. Small wonder, then, so many of the things we buy now come packaged in Tenite Polyethylene.

Many industries are finding jobs for this versatile Eastman plastic. Adapted to rapid injection molding or continuous extrusion, Tenite Polyethylene is being used as wire and cable covering... industrial tape... coatings for paper, film and foil... containers of all types ...pipe... housewares and other molded products. For more information on its properties and uses, write EASTMAN CHEMICAL PRODUCTS, INC., subsidiary of Eastman Kodak Company, KINGSPORT, TENNESSEE.

TENITE
POLYETHYLENE
an Eastman plastic

1932—EASTMAN'S 25TH YEAR IN PLASTICS—1957

For more information, turn to Reader Service card, circle No. 461

Progress with TITANIUM

Announcing...

Two new Titanium alloys for high temperature applications

MST 821... *the highest strength weldable sheet & bar alloy in 400—1000°F range*

MST 2.5Al-16V... *the first readily formable, heat treatable sheet alloy*

Two new alloys developed by Mallory-Sharon now extend the high temperature usefulness of titanium.

MST 821 is a weldable sheet and bar material with exceptional high temperature strength. It offers strengths equivalent to similar titanium alloys at temperatures *two hundred degrees* higher, in the 400 to 1000°F range. MST 821 is thermally stable, and has good ductility and formability.

MST 2.5Al-16V was developed in response to needs of the airframe industry for a sheet alloy which would be soft and formable in the solution treated condition, and which could be heat treated, after forming, to high strengths while retaining ductility. With this material, yield strength can be as low as 50,000 psi, to permit easy fabrication, then increased to 150,000 psi by heat treatment. Age hardened sheet has good short-time hot strength—about 100,000 psi yield strength up to 800°F.

These alloys, now in limited commercial production, are further evidence of rapid advances in titanium. Use Mallory-Sharon's outstanding technical experience and service on your present requirements — or future plans—in titanium.

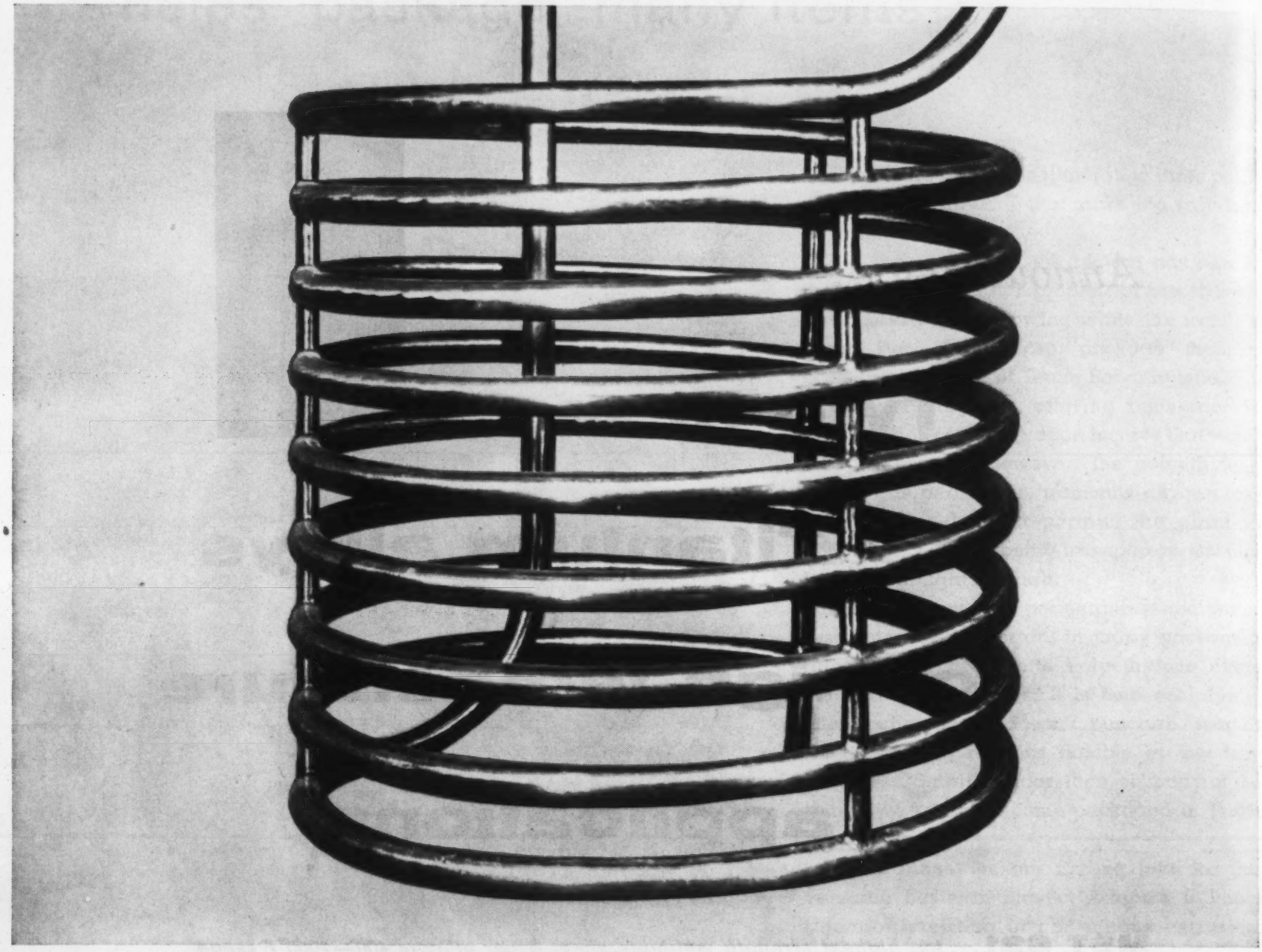
MALLORY Ti® SHARON

MALLORY-SHARON TITANIUM CORPORATION • NILES, OHIO

Producers of titanium and titanium alloy sheet, strip, plate, rod, bar, billets

For more information, turn to Reader Service card, circle No. 506

TITANIUM—available now for long service



This titanium heating coil is expected to give 5 years' trouble-free service handling a 12% sulfuric acid-bearing solution at atmospheric pressure.

Titanium coil heats sulfuric acid solution in presence of metallic sulfates

• LASTS 66% LONGER THAN SILVER
• CUTS OPERATING COSTS* BY 35%

Stress corrosion cracking limited the service life of a silver heating coil to 3 years. Maintenance was frequent and costly. The environment, a 12% sulfuric acid-bearing solution containing metallic sulfates, proved to be one in which titanium excelled. A titanium coil was installed... investigation after 9 months showed no pitting or cracking. Based on this performance, the estimated service life of this coil is 5 years, or 66% longer... with savings of 35% in operating costs.

**Includes repair labor, replacement materials and depreciation.*

For more information, turn to Reader Service card, circle No. 511

life . . . corrosion resistance . . . economy in use

Proven economies

Titanium is actually the *least expensive* metal you can use under many corrosive influences. It withstands conditions that reduce the service life of ordinary and high-alloy metals . . . cuts downtime and replacements.

Titanium offers the economy of long, trouble-free service when exposed to such corrosive environments as:

Salt Water
Marine Atmospheres
Nitric Acid
Wet Chlorine
Chlorinated Organic Compounds
Most Inorganic Chloride Solutions
Molten Sulfur
Chromic Acid
Aqua Regia
Hypochlorites & Chlorine Dioxide

TITANIUM—available today

Titanium is now readily available for non-defense applications. Standard parts of titanium are already solving severe corrosion problems in the chemical, food, pulp, paper and allied industries.

In your process development work, take advantage of the corrosion and cavitation resistance, light weight and high strength of titanium . . . important considerations for continuous flow, high temperature and pressure processes.

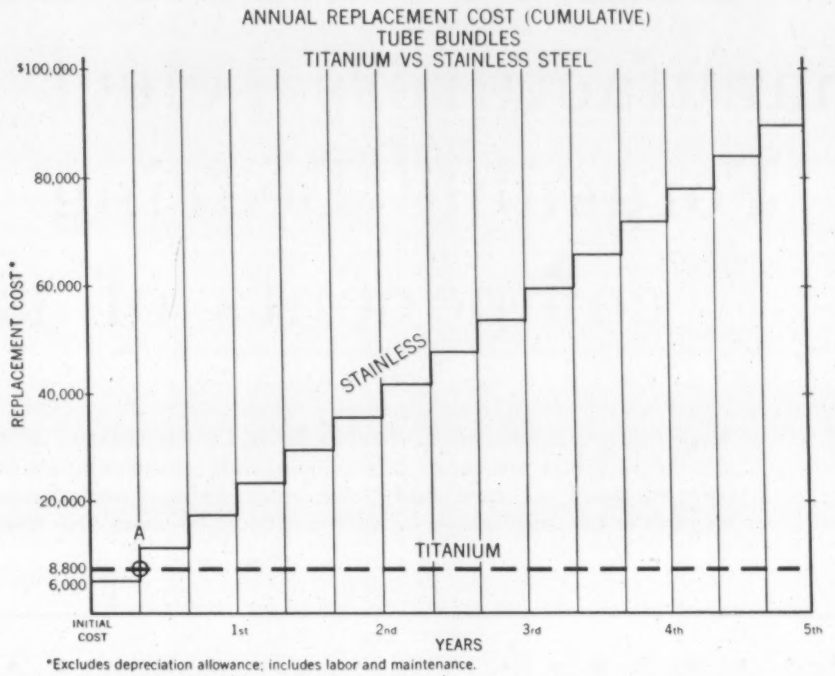
As a manufacturer and pioneer producer of titanium sponge, Du Pont has been working with leading mill-products producers and process-equipment manufacturers on the commercial development of titanium. This broad experience can be applied to *your* corrosion problems. Just get in touch with Du Pont for further information.

Be sure to mail the coupon below for an informative booklet about titanium—its properties and applications. E. I. du Pont de Nemours & Co. (Inc.), Pigments Department, Titanium Market Development Section, Wilmington 98, Delaware. (This offer is limited to the United States and Canada.)

PIGMENTS DEPARTMENT

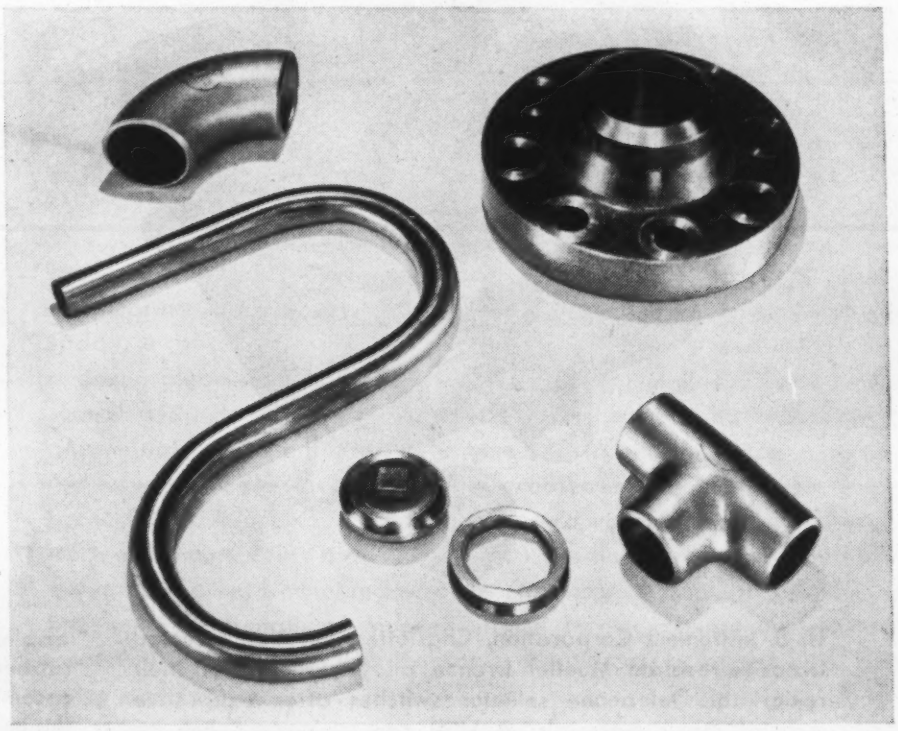
DU PONT
REG. U. S. PAT. OFF.

BETTER THINGS FOR BETTER LIVING . . . *THROUGH CHEMISTRY*



*Excludes depreciation allowance; includes labor and maintenance.

ANOTHER INSTANCE of titanium's long life is shown by this cost/service graph comparing titanium vs. stainless condenser tubes handling 60% nitric acid. Titanium tube bundle costs $8,800 vs. $6,000 for same unit in stainless. The $2,800 difference is absorbed within 4 months of service. Based on service life of 10 years, titanium will save at least $162,000 maintenance and replacement costs.



NOW AVAILABLE. Titanium parts and fittings like this tee joint, 90° weld ell, welding neck flange, pipe bend and powder metallurgy valve trim are just a few examples of standard commercial items now made of titanium.

Pioneer producer of TITANIUM SPONGE

Please send me more information on titanium. I am interested in evaluating titanium for these applications:

_____

_____

_____

E. I. du Pont de Nemours & Co. (Inc.)
Titanium N-2496, MDE-2, Wilmington 98, Delaware

*Name*_____ *Title*_____

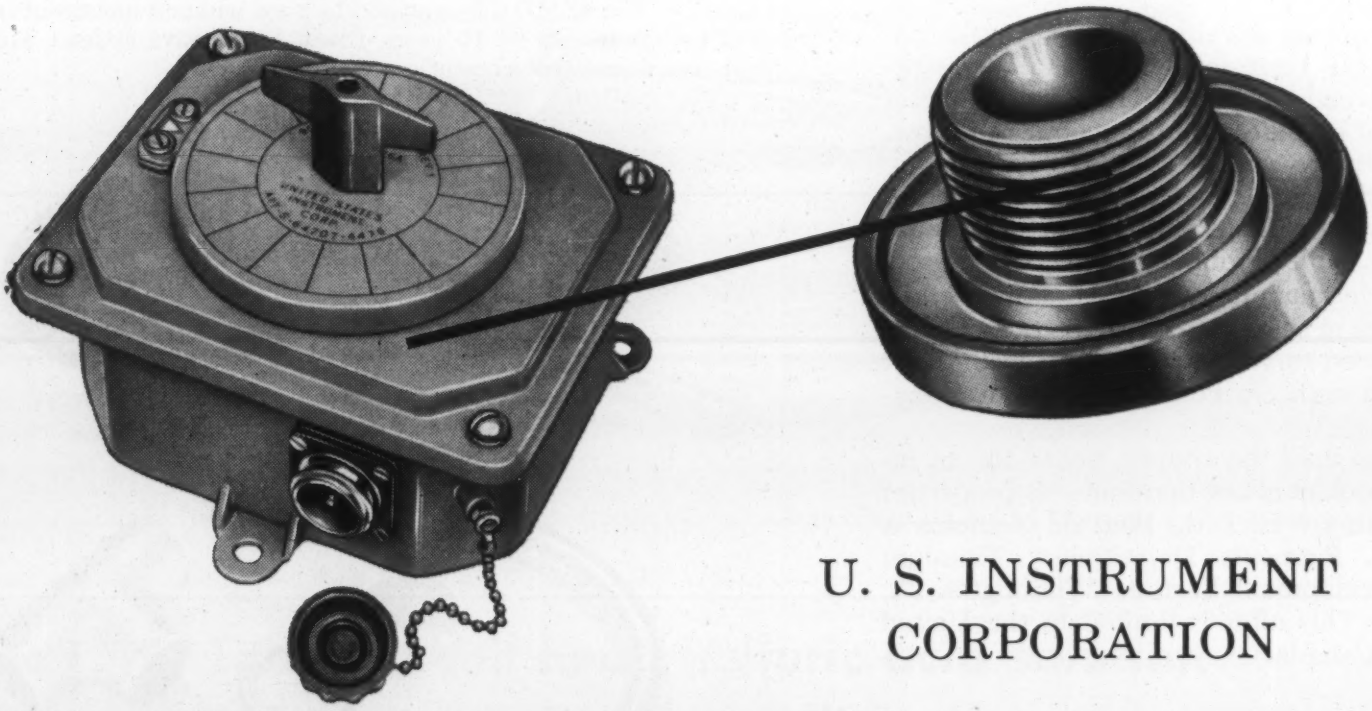
*Firm*_____

*Address*_____

*City*_____ *Zone*_____ *State*_____

Three more nationally known manufacturers select Mueller Brass Co. Forgeable Bearing Alloys for vital components of their products

In ever-increasing numbers, Mueller Brass Co. specialized alloys are being specified by manufacturers of top-quality products. In a series of continuing advertisements, we have presented case histories of successful applications, to which we now add three more distinguished companies who are incorporating Mueller Brass Co. forgeable bearing alloys in their products to meet the demands of widely divergent operating conditions.



U. S. INSTRUMENT CORPORATION

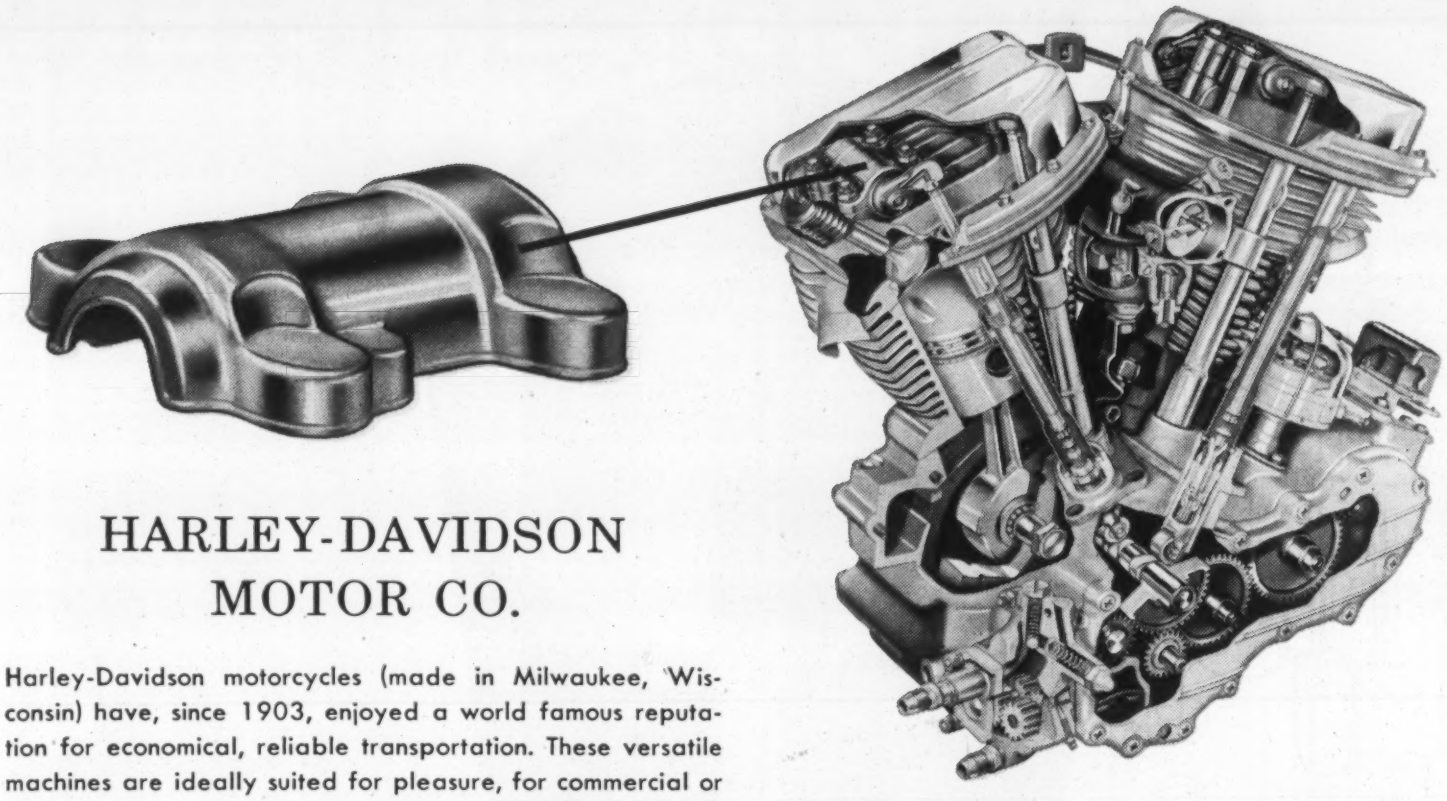
U. S. Instrument Corporation, Charlottesville, Va., selected abrasive-resistant Mueller bronze alloy bushings for their remarkable telephone selector switches after exhaustive tests of many materials. A vital communications link on today's U. S. Naval vessels, these sound-powered telephone circuits must meet rigid Navy performance-standards. Such phones, for example, must have selector switches which are capable of rotating for a minimum of 50,000 torturous cycles . . . 360° clockwise, followed by 360° counter-clockwise. In addition, the "O" ring must still form a water-tight seal AT THE END OF THE TEST! Of the many tested, a Mueller Brass Co. special manganese bronze alloy was the best one meeting these rigid specifications.

There were other important reasons why these bushings were chosen by U. S. Instrument Corporation for this application. Resistance to abrasive action against the rubber "O" ring was a prime one . . . then, too, the stem assembly suffered severe pounding through the action of the indexing mechanism which, prior to the use of the Mueller Brass Co. alloy, caused repeated seizure of the component parts. In this particular application, the part was fabricated on an automatic screw machine rather than produced as a forging. The versatility of Mueller Brass Co. alloys makes them readily adaptable to the most economical method of fabrication dependent upon the size, shape, and end-use requirements of the part.

In commenting on the success of this part, U. S. Instrument Corporation praised the alloy for its tensile strength (ordinary brasses could not withstand the 2000 ft. lb. impacts without deformation), for its machinability and corrosion-resistance.

40 OUR 40TH YEAR MUELLER BRASS CO 1917-1957

MUELLER BRASS CO.



HARLEY-DAVIDSON MOTOR CO.

Harley-Davidson motorcycles (made in Milwaukee, Wisconsin) have, since 1903, enjoyed a world famous reputation for economical, reliable transportation. These versatile machines are ideally suited for pleasure, for commercial or business use, as well as the grueling demands of law enforcement work. Harley-Davidsons boast a dependable engine . . . one which can roll up an astounding mileage record with little or no care. The painstaking selection of every engine component is one important reason for this reliability. The new twin-cylinder Harley-Davidson 74 OHV employs Mueller Brass Co. bronze alloy forgings in the form of rocker-arm bearing caps. Subjected to violent temperature changes, fast starts and stops and road shock, Mueller forgings are proving again and again that they have the ability necessary to withstand almost any punishment . . . and still provide unfailing service.

JACOBSEN MFG. CO.

Jacobsen Mfg. Co., Racine, Wisconsin, was among the first to produce a practical power mower for home use. That was more than 35 years ago! Today, Jacobsen power-mower dependability is evident itself in more than a dozen gleaming new models such as the popular Pacer, Lawn Queen, Manor and others. One of the most reliable components in the always dependable Jacobsen hi-torque engine is a Mueller Brass Co. connecting rod forged from special bronze alloy. Jacobsen mowers with Mueller-forged connecting rods are called upon by some commercial users to operate as much as 8 hours daily, 6 days a week . . . perhaps as much as 2000 hours a year. In searing summer temperatures, thru hours of constant operation, the high uniform strength of Mueller bronze forgings constantly withstands pounding and vibration with the same conspicuous success as in its many other applications.

Why not investigate these specialized alloys for your own products. We welcome your inquiries. Our engineering staff will be happy to make specific recommendations. Both on the proper alloy and the best method of fabrication to meet your needs . . . exactly. Our engineering manuals show many, many examples of how American manufacturers have used these alloys to great advantage.

• WRITE TODAY FOR THE ENGINEERING MANUAL YOU NEED

Mueller Brass Co. Forgings
Engineering Manual H-58565 ☐

Tuf Stuf Aluminum Bronze Alloys
Engineering Manual H-58563 ☐

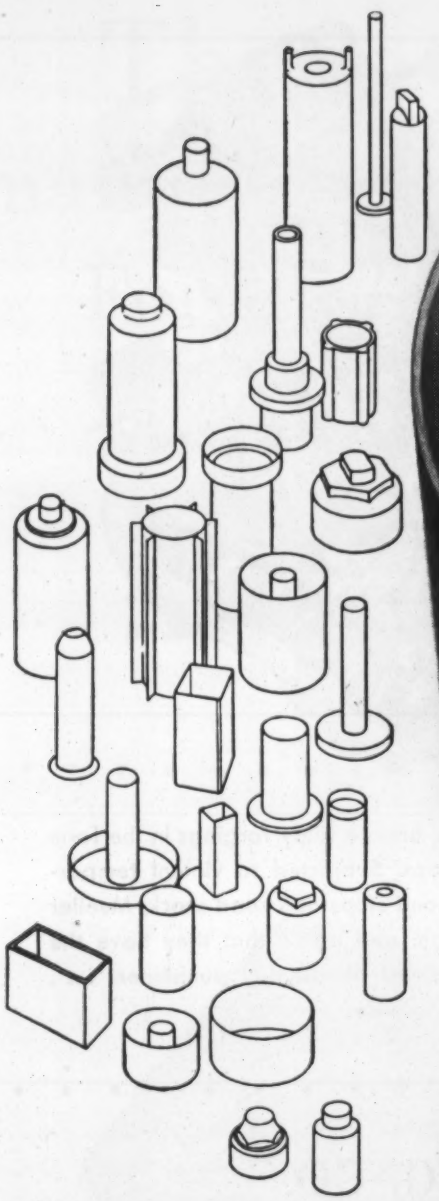
"600" Series Bearing Alloys
Engineering Manual FM-3000 ☐

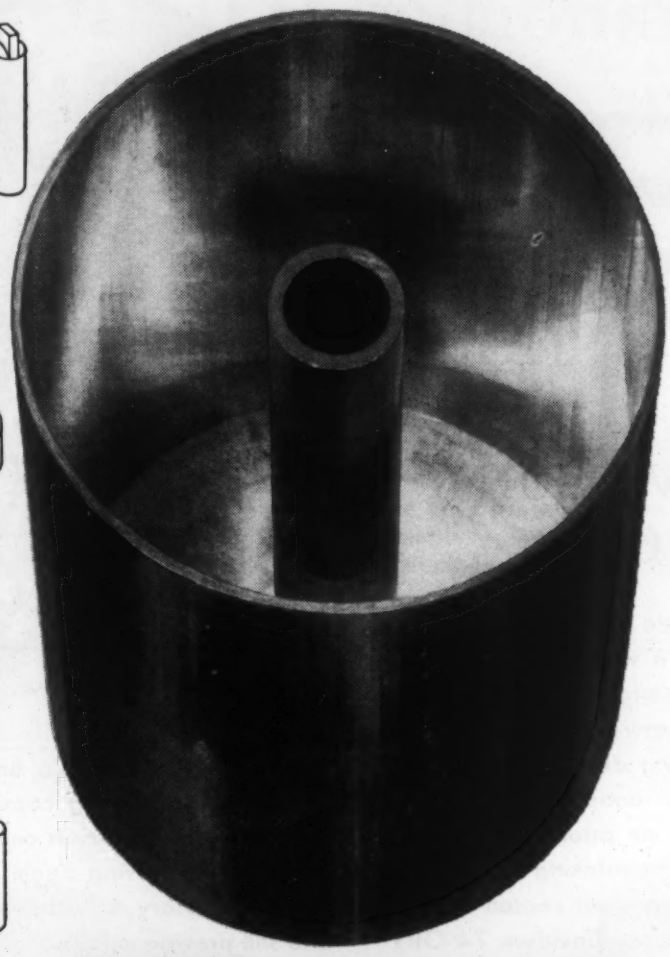
Copper Base Alloys in Rod Form
Engineering Manual FM-3010 ☐

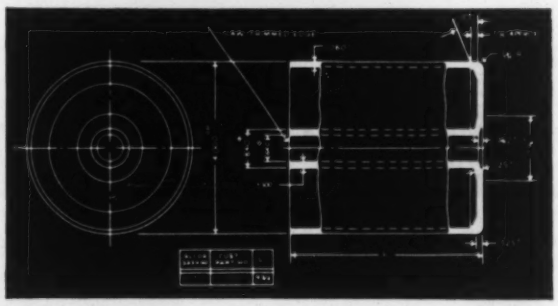
227

P O R T H U R O N 2 1 M I C H I G A N

For more information, turn to Reader Service card, circle No. 429







made in one piece–in one stroke as an **ALCOA IMPACT**

Faced with the problem of designing this center-tube impact as a one-piece part, a designer who is not familiar with Alcoa® Impacts would throw up his hands. Then he would break out the slide rule to start figuring costs on welding the center tube to the base. After that, he'd have to puzzle out an inexpensive way to join the base to the side wall. The fact is, he never would figure out a way to do it economically.

To the informed designer who *is* familiar with Alcoa Impacts, this would be just another routine job that he could rely on Alcoa's Impacts experts to knock out for him. In spite of its rather complicated design, it is formed (as are all impacts) in a fraction of a second, with a single stroke of the punch. It is a strong, lightweight, seamless part. Actually made better, stronger and more economically than it could have been by *any* other fabricating method.

To guide your thinking, check the handy rules of thumb below. Any part that is a closed-end tubular part, or cup-shaped, should be considered as an Alcoa Impact. In one shot, we can make round, oval, square or special shapes. Ribs, splines, flutes or other functional or decorative patterns can be incorporated on the inside or outside. Let your imagination go to work; we're anxious to go to work for you.

To get your imagination started, send for Alcoa's design manual, *Alcoa Impacts—Metal in Motion*. You'll find it loaded with design tips and ideas that have saved other designers a lot of money. For on-the-spot assistance, call your nearest Alcoa sales office. It's listed under "Aluminum" in the Yellow Pages of your telephone directory. An Alcoa sales engineer will put his solid technical know-how at your disposal. Aluminum Company of America, 1994-M Alcoa Building, Pittsburgh 19, Pa.

Some Impact Rules of Thumb—
Check your problems against this list:

1. Parts requiring hollow sections—either tube or cup-shaped with one end closed.
2. Parts with walls or surfaces requiring zero draft.
3. Parts requiring lengths up to eight or ten times the diameter.
4. Parts requiring the strength of forgings.
5. Parts requiring tolerances down to $\pm 0.005''$.
6. Parts requiring ribs, bosses or fins as integral parts.
7. Parts requiring low unit cost in mass production. (Often the savings in machining, fabrication and assembly made by impacts amortize tooling in relatively short runs.)

ALCOA ALUMINUM IMPACTS
ALUMINUM COMPANY OF AMERICA

YOUR GUIDE TO THE BEST IN ALUMINUM VALUE

NEW!
"ALCOA THEATRE"
Exciting Adventure
ALTERNATE MONDAY EVENINGS

For more information, turn to Reader Service card, circle No. 472

OVER-DESIGNING?

If you are designing bronze parts for mass production, there is a good chance that you are specifying a more costly alloy than you need.

ASARCO's patented continuous-casting process produces alloys according to SAE, ASTM and Government specifications. But their performance is entirely unlike that of similar alloys cast in sand or permanent molds. Relatively low-cost alloys cast by the ASARCO process perform like more expensive alloys cast by other methods.

For example, compare Continuous-Cast SAE 660 (ASARCON 773) with more expensive sand-cast alloys:

	Typical Yield Strength	Typical Impact Strength	Brinell Hardness
ASARCON 773	27,000 psi	12.5 ft.-lbs.	72
Sand-Cast SAE 62	20,000 psi	8.7 ft.-lbs.	65
Sand-Cast SAE 64	17,000 psi	8.2 ft.-lbs.	62

Unless you've checked to see whether the unique ASARCO bronzes can give you what you need, there's a possibility that you're over-designing. You may even be able to replace aluminum and manganese bronzes with low-cost ASARCON Continuous-Cast bronzes under certain conditions. Over-designing can be expensive in mass production, even if you are spending only a penny or two extra per pound of bronze.

ASARCON 773 (SAE 660) is readily available from stock in a wide range of sizes. An added bonus is the fact that ASARCON 773 is exceptionally free-machining. Rods, tubes, and numerous "extruded" shapes up to 9 inches in diameter are cast to order by ASARCO in more than 20 alloys.

We'll be happy to send you a free booklet describing the process and the product.

Continuous-Cast Products Department

AMERICAN SMELTING AND REFINING COMPANY

Perth Amboy Plant, Barber, New Jersey • Whiting, Indiana

WEST COAST SALES AGENT: Kingwell Bros. Ltd., 457 Minna Street, San Francisco IN CANADA: Federated Metals Canada, Ltd., Toronto and Montreal

For more information, turn to Reader Service card, circle No. 476

DESIGNING WITH ALUMINUM

This is one of a series of information sheets that discuss the properties of aluminum and its alloys with relation to design. Extra or missing copies of the series supplied on request. Address: Advertising Dept., Kaiser Aluminum & Chemical Sales, Inc., Department PD-1, 919 No. Michigan Ave., Chicago 11, Ill.

NO. 26

ADVANTAGES OF ALUMINUM FOIL STRIP FOR ELECTRICAL WINDINGS

Conversions from round copper wire to aluminum interleaved strip windings are bringing improved design, better performance and lower costs to a wide range of mass production applications.

ALUMINUM RIBBON, interleaved with insulation material, may be used successfully in place of copper in such applications as: transformers for radio and television; motor starters and aircraft accessories; field and rotor windings for motors and generators; coils for solenoids, relays and ignition devices; chokes, filters and a vast range of similar electromechanisms and electronic devices.

Conversion to Foil Strip Offers Design Advantages

Although the design of any electromagnetic unit depends upon its specific application requirements, aluminum ribbon conductor offers several advantages to *all applications* converted from round copper wire:

1. *Reduction in void space often allows equivalent cross-section size.* Whereas round copper wires leave unfilled spaces between strands, the flat aluminum ribbons lie neatly together in a compact mass free of voids. This can often allow equivalent winding cross-section size. Where cooling ducts and layer insulation are used, the aluminum ribbon and interleaving insulation will almost always fit the same winding gap as copper.
2. *Excellent heat dissipation reduces operating temperature.* Aluminum conducts heat better than any insulation or impregnating material. A ribbon-wound coil has substantially the same temperature throughout a layer of conductor because each layer is a solid conductor and dissipates heat to the outside. Absence of voids eliminates formation of local "hot spots"—has reduced temperature as much as 100°F. This control of temperature normally allows a reduced aluminum cross-section for equal current carrying capacity.
3. *Lower space factor helps reduce cost and weight.* Because ribbon wound coils generally operate at temperatures 20 or more degrees (F.) lower than wire wound coils, it is possible to reduce the 1.64:1 aluminum-to-copper area ratio that is theoretically necessary. In actual use, area factors are about 1.5 and occasionally have been as low as 1.25, making possible weight reductions of over 50% . . . with cost savings of 30 to 40% for copper wire conversions in sizes #24 or larger.
4. *Manufacturing method reduces problem of conductor tensile strength.* Because wire-drawing tensions are absent in manufacturing the slit aluminum ribbons, and because aluminum strip has better heat dissipation and lowers coil temperatures, comparative conductor strength has little significance. Aluminum ribbon conductor is readily available and readily adaptable to high production techniques.
5. *Effective joining methods available at low cost.* A wide variety of joining techniques and equipment—all proved in thousands of high-production electrical devices—offer economy equal or better than copper for both initial cost and maintenance.

Two Design Approaches Meet Conversion Problem

The fundamental design problem in converting from copper to aluminum conductor is, of course, to provide for and accommodate the additional coil cross-section needed for equal conductance and reactance, and at the same time provide equal dissipation of heat. Two basic approaches may be taken to this problem.

First, the conductor cross-section may simply be increased by the appropriate factor (1.5) to give the same ampere turns and resistance; or second, the wiring area may be changed to allow a better ratio of conductor to insulation where space is critical or the coil may be split and connected in series to further help this conductor to insulation ratio.

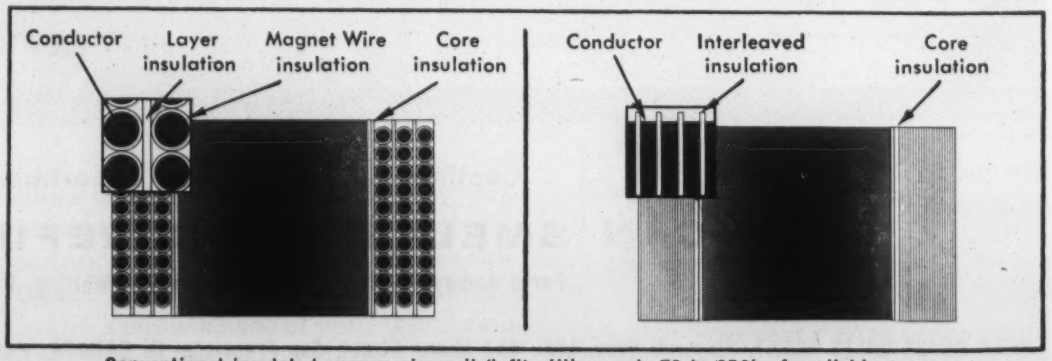
Designing for a compromise between these two approaches is favored by the physical shape of aluminum strip conductor, and allows the designer to make use of the advantages of both approaches. The aluminum ribbons are produced by slitting from foil, which may be mill-rolled to any requested thickness, and thus are available in any desired combination of gauge and width, unrestricted to standard gauge sizes. And—to the designer's advantage—the aluminum conductor proportions may be exactly determined *by the rectangular geometry* of the wiring cross-section.

Elimination of the voids between circular conductor sections together with the better dissipation of heat due to this design results in working temperatures normally about 20°F. cooler than in round wire. Some ribbon wound coils have reduced "hot spot" temperatures by as much as 100°F., and have accepted without damage excess loadings that have destroyed electromagnetically-equivalent copper wire wound coils.

When aluminum ribbon conductor is substituted for copper wire to give equal current carrying capacity and equivalent resistance, the aluminum conductor assembly is little or no larger and *sometimes smaller*—than its copper prototype.

Insulation Need Not Have High Dielectric Strength

Because the potential between successive wraps is usually low, the insulation materials between layers normally does not require high dielectric



Conventional insulated copper wire coil (left) utilizes only 70 to 85% of available space. Aluminum interleaved strip conductor coil (right) utilizes up to 97% of overall space.

strength. Condenser paper 0.00025" in thickness may be used in many applications where space is highly critical.

"Mylar"* and "Teflon"* plastics have excellent dielectric, tensile and scuffing strength. They are available in gauges down to 0.00025" and accept, without aging, higher temperatures than paper. The higher cost of "Mylar" for Class B insulation, and the still higher cost of "Teflon" for Class H insulation are justified for conversion of high operating temperature coils.

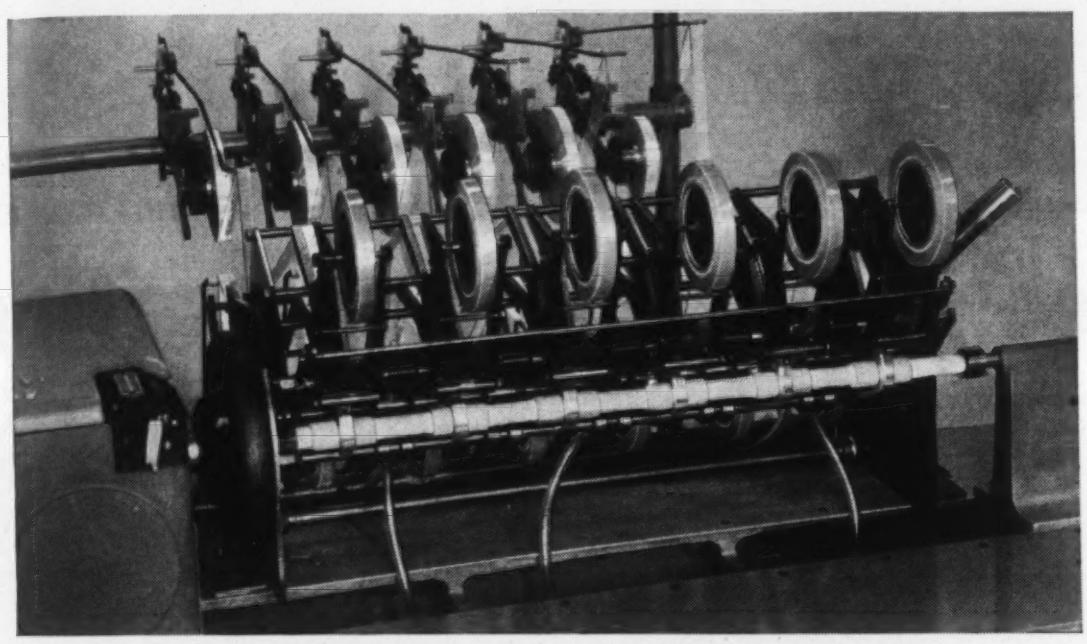
Fixed coatings such as resins and enamels are efficient and eliminate separate interleaving. Although they are not commercially available at this time, should they become more readily available in the future, this factor would further reduce material cost.

Anodized conductor similarly needs no separate insulation, resists temperatures up to 750°F., and eliminates the need for separate interleaving materials. Extreme care is necessary to prevent edge crazing of the anodic coating during the winding operations. The anodic coating is inherently porous and requires sealers against moisture. Such sealers are presently limited to a maximum temperature of about 400°F.

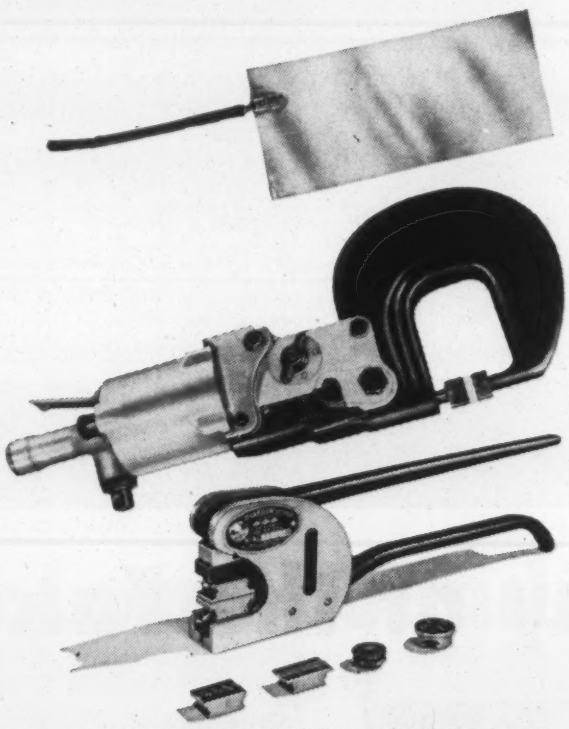
The strip insulation lowest in weight and cost is condenser tissue of suitable gauge. The paper is limited by a tendency to become brittle after lengthy exposure to temperatures above 250°F., but otherwise is an excellent general purpose insulator. Because of its natural porosity, it may be readily impregnated with resin sealers for protection against moisture, or with sealer-adhesive materials to bind the interleaved coil into an integral unit.

Most of the existing machinery for handling single-wound, heavier size conductors can be adapted readily to the use of aluminum ribbon by adding little more than an unwinding reel, a suitable tension device and guides for the insulation and aluminum strip.

Equipment for multiple winding of smaller coils often is too specialized for easy adaptation, but usually may be converted by more detailed alterations. In present practice, both conductor ribbons and insulation strips are wound from reels of pre-slit material.



Modern foil coil machine designed specifically for aluminum ribbon coil windings. (Universal Winding Company, Providence, R. I.)



Above: Tinned copper wire pressure welded to aluminum foil. **Below:** Koldweld tools made by Utica Drop Forge and Tool Division of Kelsey-Hayes Company.

*Dupont trade names.

Tested Joining Methods Offer Economy, Versatility

The joining of round, flat, and stranded leads of aluminum or copper to ribbon conductors of aluminum has been accomplished in a variety of ways. Soldering or brazing of leads and terminals may be accomplished by use of suitable aluminum fluxes and solders, by ultrasonic soldering techniques, or by the use of fiber-glass brushing in conjunction with recommended aluminum solders on the heavier gauge materials.

Cold or hot pressure-welding is an extremely economical method by which the metals are pressed into plastic-flow merging of surfaces to give a true weld. Flash welding and inert arc welding also produce good welded joints. Standard crimping procedures have been used effectively although the ribbon conductor shape also permits punching to receive wide flange connecting parts without need for crimping.

Where dissimilar metal joints are used and are susceptible to high humidity conditions, suitable resin sealers may be applied at the joint to minimize the possibility of galvanic corrosion.

The operating and cost efficiencies of aluminum strip conductor are most marked when replacing copper wire of #24 AWG or larger, but savings have been realized by conversions through #30 gauge. Economies in conductor cost, including insulation, have been recorded from 30 to 40%.

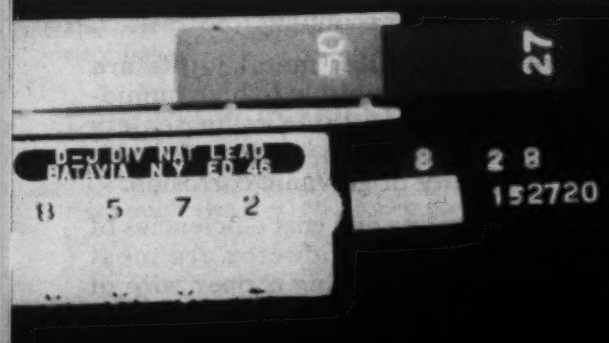
Kaiser Aluminum does not manufacture electromagnetic coils or insulation materials, but has wide availabilities of aluminum ribbon conductor and a special technical staff to assist coil manufacturers and users in all details relating to the use of its conductor materials in their products. Inquiries for such assistance are welcomed and sample coils can be fabricated to customer specifications for their evaluation in possible conversions.

For immediate attention to your request for this technical service or samples, or for more detailed information, contact the Kaiser Aluminum sales office listed in your telephone directory. Kaiser Aluminum & Chemical Sales, Inc., *General Sales Office*, Palmolive Bldg., Chicago 11, Illinois; *Executive Office*, Kaiser Bldg., Oakland 22, Calif.

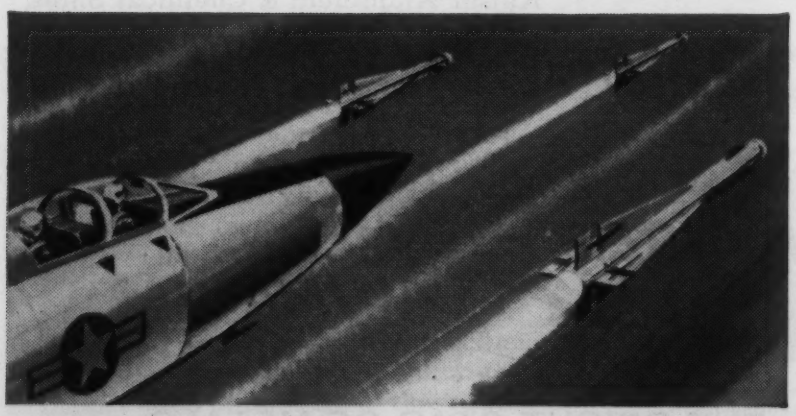
see our catalog in
PRODUCT DESIGN FILE
or write for copy

KAISER ALUMINUM
THE BRIGHT STAR OF METALS

Now...from Doehler-Jarvis...die castings of



X-ray of the Falcon's fin proves t



The Falcon is an air-to-air missile built by Hughes Aircraft Company for the U. S. Air Force. Its light weight die cast stabilizer fins resist severe strain during course changes. It uses other Doehler-Jarvis die castings also.

Now *you* can have structurals die cast to standards as high as those for primary aircraft structurals*.

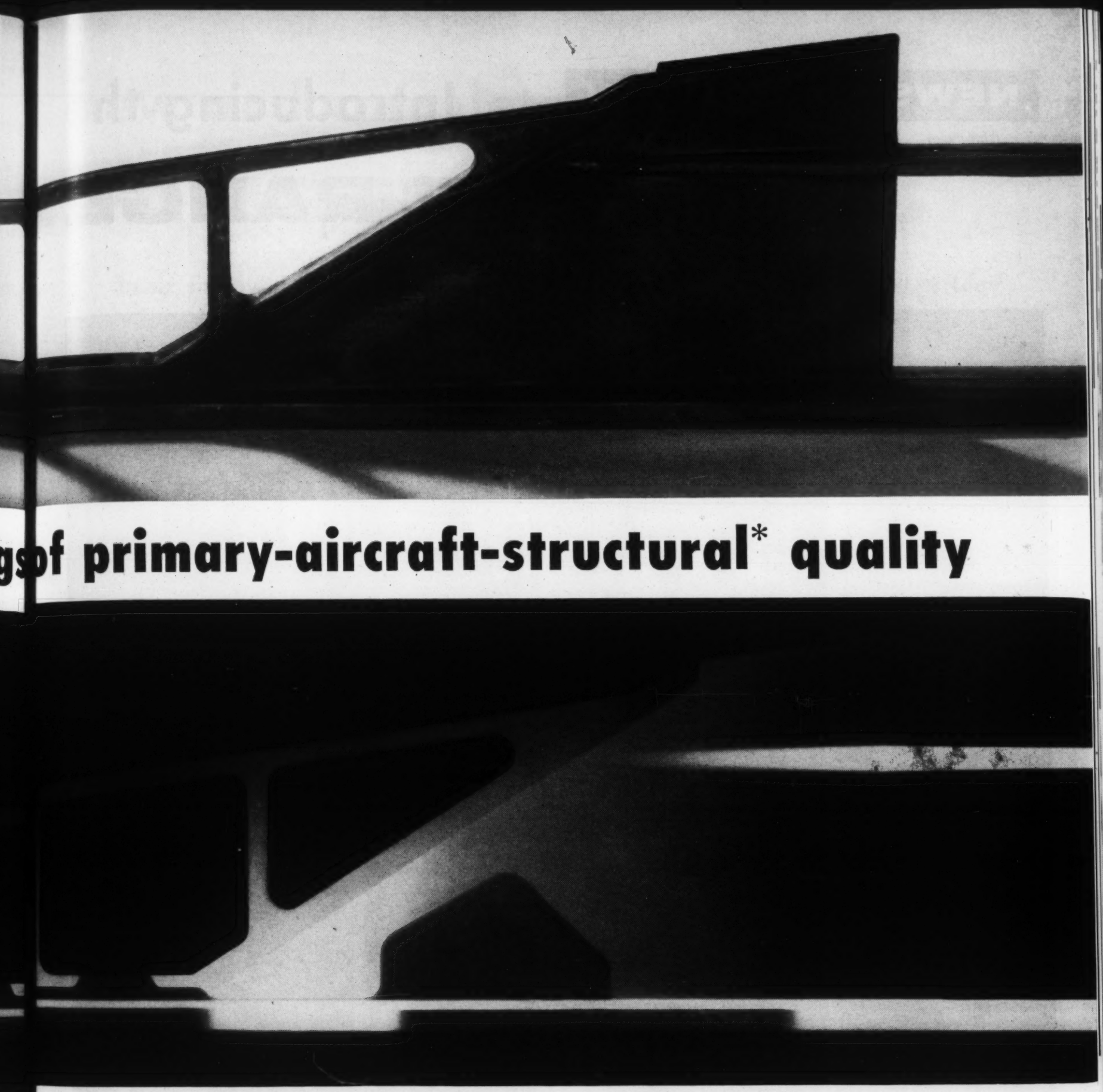
Die cast! With all the economy, precision, surface superiority, ease of assembly that implies. Die cast of aluminum, or of a high-purity magnesium alloy, like the 42" Falcon stabilizer fin.

They said it couldn't be done!

But there you see such a structural! Along with X-ray proof of soundness, uniformity, primary-aircraft-structural* quality.

Mind you! The Falcon fin is in commercial production. Doehler-Jarvis has die cast thousands. Each has had to pass 73 inspections before acceptance . . . including 100% X-ray.

In *one* control, sections of castings are continuously tested for tensile strength. In this examination of physical properties, the castings normally exceed tensile specifications by 15% or



gsof primary-aircraft-structural* quality

estheir uniformity and soundness

more. Quality is so high there has never been a single test below specification.

How did this come about?

Like many developments in die casting, this one started with a customer's need . . . Hughes Aircraft's.

They, and the Armed Services, needed such castings. The parts *might* be made other ways. But at what cost! What sacrifice in weight — and materials! If it *could* be die cast, if there *were* a magnesium alloy able to stand supersonic air stresses . . .

It took a while. But, with close cooperation from engineers of both Doehler-Jarvis and Hughes, the way was found.

Now you can list die castings of primary-aircraft-structural* quality among D and J availabilities. Get them from any Doehler-Jarvis plant.

*A primary aircraft structural is a major load-bearing component member any single failure of which would result in loss of the aircraft.

Doehler-Jarvis

DIVISION OF NATIONAL LEAD COMPANY

General Offices: Toledo 1, Ohio

In Canada:

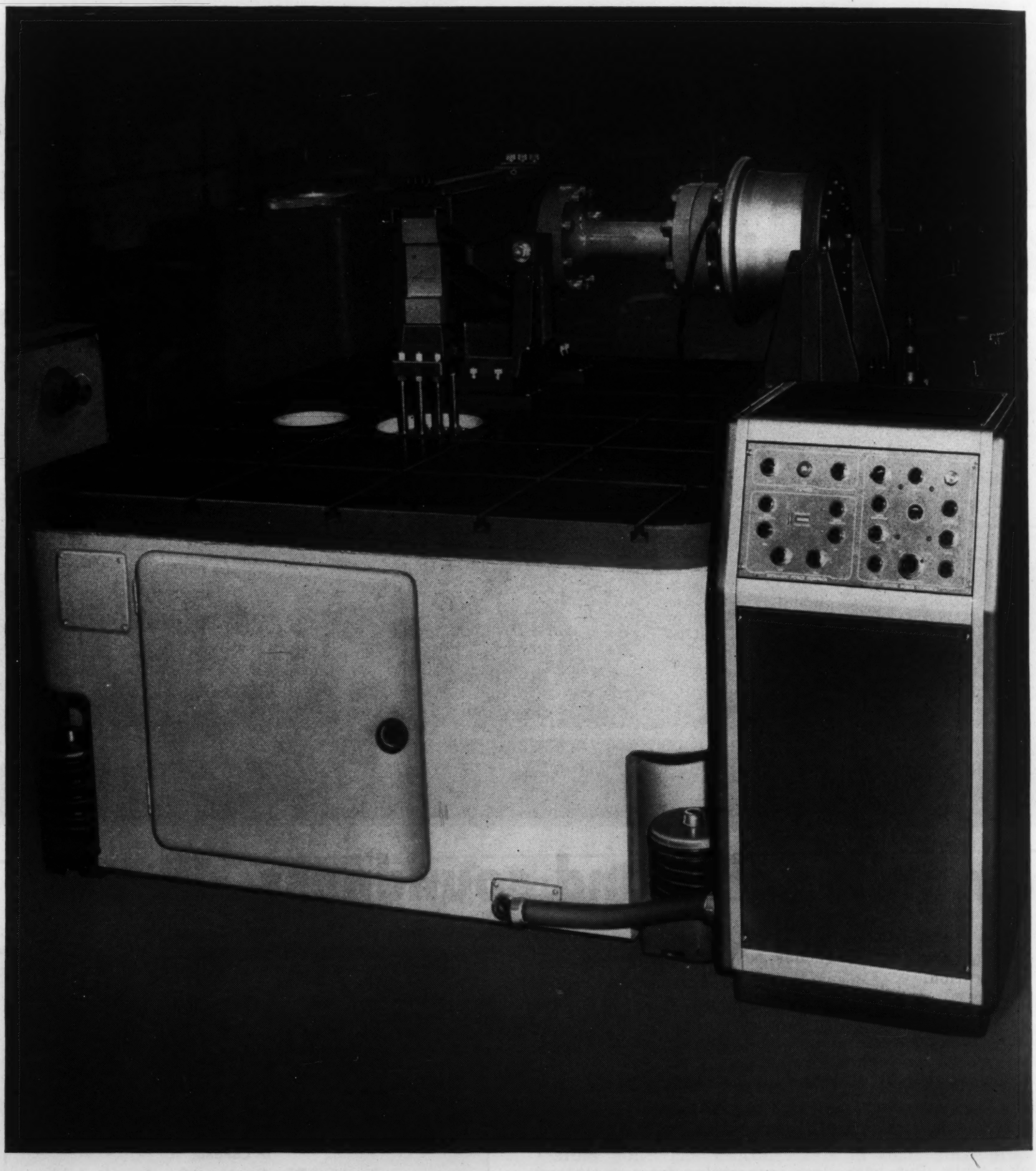
Barber Die Casting Co. Limited

Hamilton, Ontario

For more information, turn to Reader Service card, circle No. 502

NEWS FROM B-L-H

Introducing the I-V MULTI-RANGE



Fixture mounted on Model I-V 20 is putting an aircraft brake assembly through a series of fatigue tests. Separate console locates electronic control equipment away from vibration.

new and complete line of

FATIGUE TESTERS

In six sizes with capacities ranging from 200 to 120,000 lb. at the high load station and amplitudes up to ± ¾ in. maximum at the high amplitude station

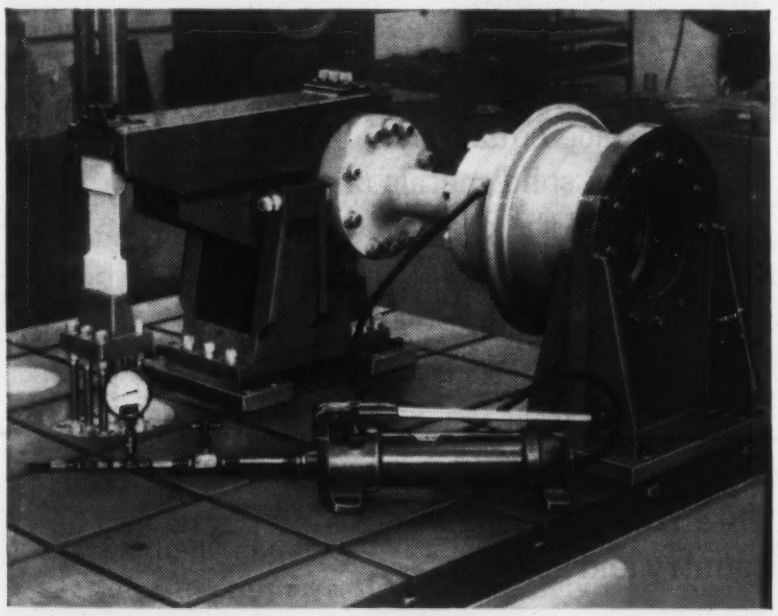
Now ready for delivery, the new B-L-H line of I-V multi-range fatigue testing machines meets an unusually broad variety of requirements. Whether for production testing of machine members, components and structural assemblies, or for testing research specimens, I-V Fatigue Testers offer you high accuracy, combined with maximum versatility and simplicity of operation. By use of suitable fixtures, the possible combinations of static and dynamic loads permit the simulation of almost any service condition.

A 5 to 1 force-multiplying fixture can be added to all models. For example, it will increase the load capacity of Model I-V 120 from 120,000 to 600,000 lb.

A unique feature of the I-V Fatigue Tester is its multi-range design. This provides two loading stations, one for applying full force capacity and one for high amplitude tests up to ± ¾ in. maximum. Amplitude limits, automatically maintained while the machine is running, permit stopping of a test just before complete specimen separation to allow metallurgical examination of the region of crack initiation.

The three smaller models, I-V 02, I-V 1 and I-V 4, are available in operating frequencies of either 1200 or 1800 cpm; the larger models, I-V 20, I-V 50 and I-V 120, of only 1200 cpm.

For the best in testing, see B-L-H first. You can choose from the industry's most complete line of testing equipment, including tension, compression, creep, fatigue, impact or torsion. For more information on the I-V Fatigue Tester, write for a free copy of Bulletin 4217. Or ask to have a B-L-H representative stop in and see you.



Closeup of wheel-and-brake test fixture showing hydraulic pump used to apply brake pressure.

Model I-V 20H (with furnace and high temperature fixture). Special control panels record temperature and creep.

BALDWIN · LIMA · HAMILTON

Electronics & Instrumentation Division

Waltham, Mass.

Testing machines • SR-4® strain gages • Transducers

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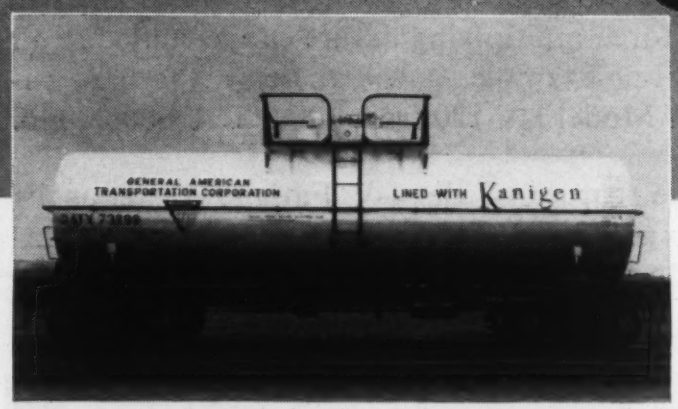
WHEREVER YOU NEED THE PROTECTION OF NICKEL YOU CAN USE LOW-COST



KANIGEN®

Kanigen® nickel-alloy coatings provide corrosion resistance and product contamination protection to process equipment.

With Kanigen—a hard, uniform, chemically-deposited coating—you can protect equipment of any size—from the interior of a huge dryer to a tiny pressure-relief valve.

This inexpensive nickel-alloy coating will do almost anything that nickel will do. Kanigen gives low-cost metals a hard, resistant nickel-alloy surface equal to or better than expensive alloys, solid metals or clad materials, at a fraction of the cost.

Your equipment or parts can be barrel-coated, rack-coated or jig-coated with Kanigen. General American has Kanigen plants at East Chicago, Indiana; Sharon, Pennsylvania, and Compton, California. Kanigen is also available from licensees in other parts of the country and abroad.

KANIGEN GENERAL AMERICAN TRADE MARK

KANIGEN *is a trademark which identifies chemical nickel coating by GENERAL AMERICAN TRANSPORTATION CORPORATION and its licensees, the product resulting therefrom and compositions produced by them for use in chemical nickel coatings.*

GENERAL AMERICAN TRANSPORTATION CORPORATION
135 South La Salle Street • Chicago 90, Illinois

For more information, turn to Reader Service card, circle No. 499

For more information, circle No. 544

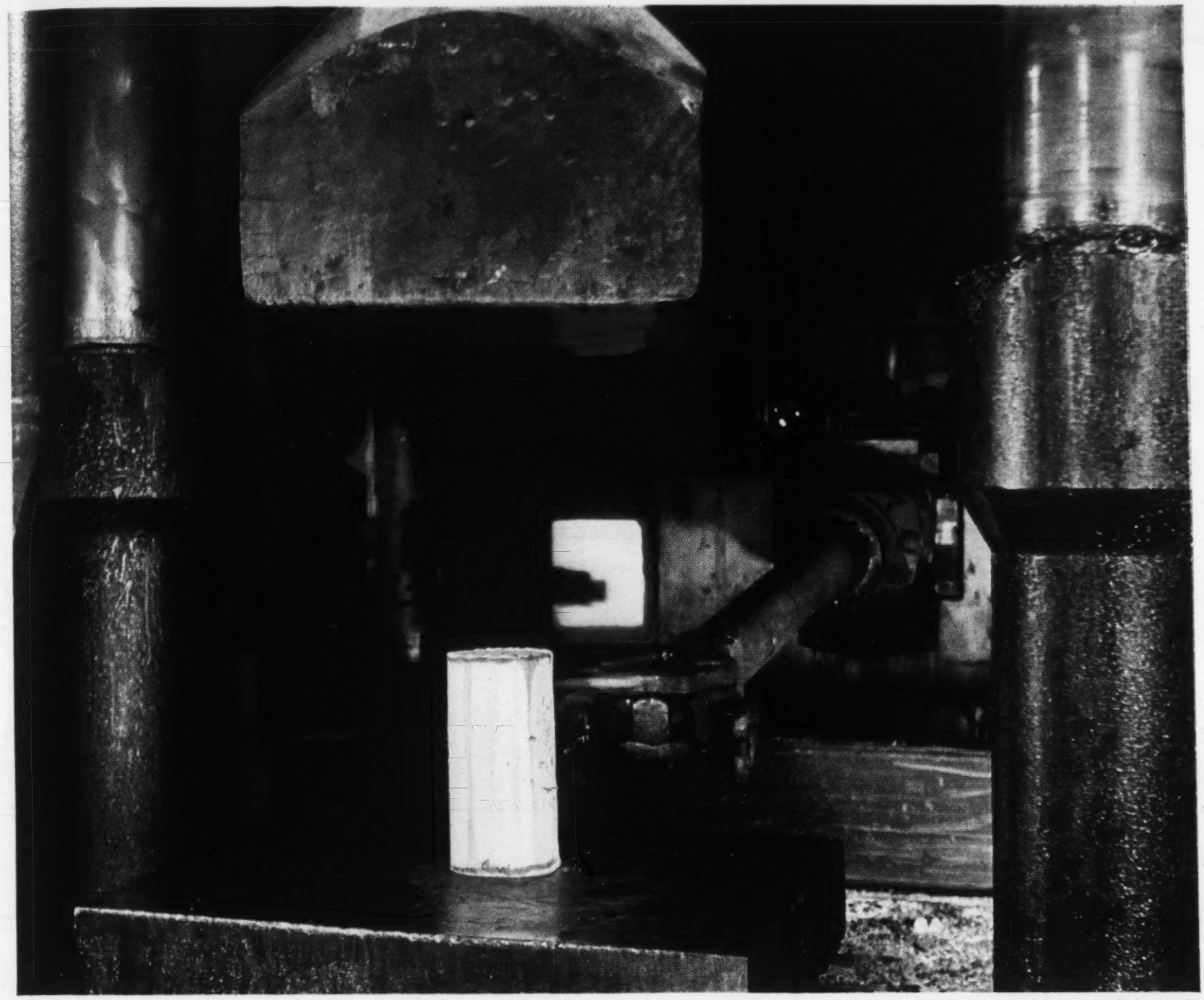


Photo courtesy Cameron Iron Works, Inc., Houston, Texas, and Linear, Inc., Philadelphia, Pa.–Manufacturers of Precision Molded Seals

How to make 4 lbs. of rubber pack a 1000-ton load

To batter a billet into rough shape, prior to machining, is no chore for the hydraulic forging press shown above. A press of a button and it works down the hot steel with a thousand tons of pressure every several seconds.

But it was a chore to find an adequate seal for the big press ram. Its designers looked long and hard before they found a split ring packing that would not leak under the high pressure and fast traverse.

Twin secret of the success of the fabric-reinforced, precision-molded, rubber rings now used are their unique design–and CHEMIGUM. A series of internal, V-shaped dams and external abutments seal off any labyrinth leakage, while the CHEMIGUM assures a lastingly tight fit.

The reasons why the ring manufacturer uses CHEMIGUM for this and other precision seals are its excellent resistance to oil, heat and abrasion and its unusual ease of processing. How can this outstanding combination of properties benefit your product? For details, write to Goodyear, Chemical Division, Dept. L-9437, Akron 16, Ohio.

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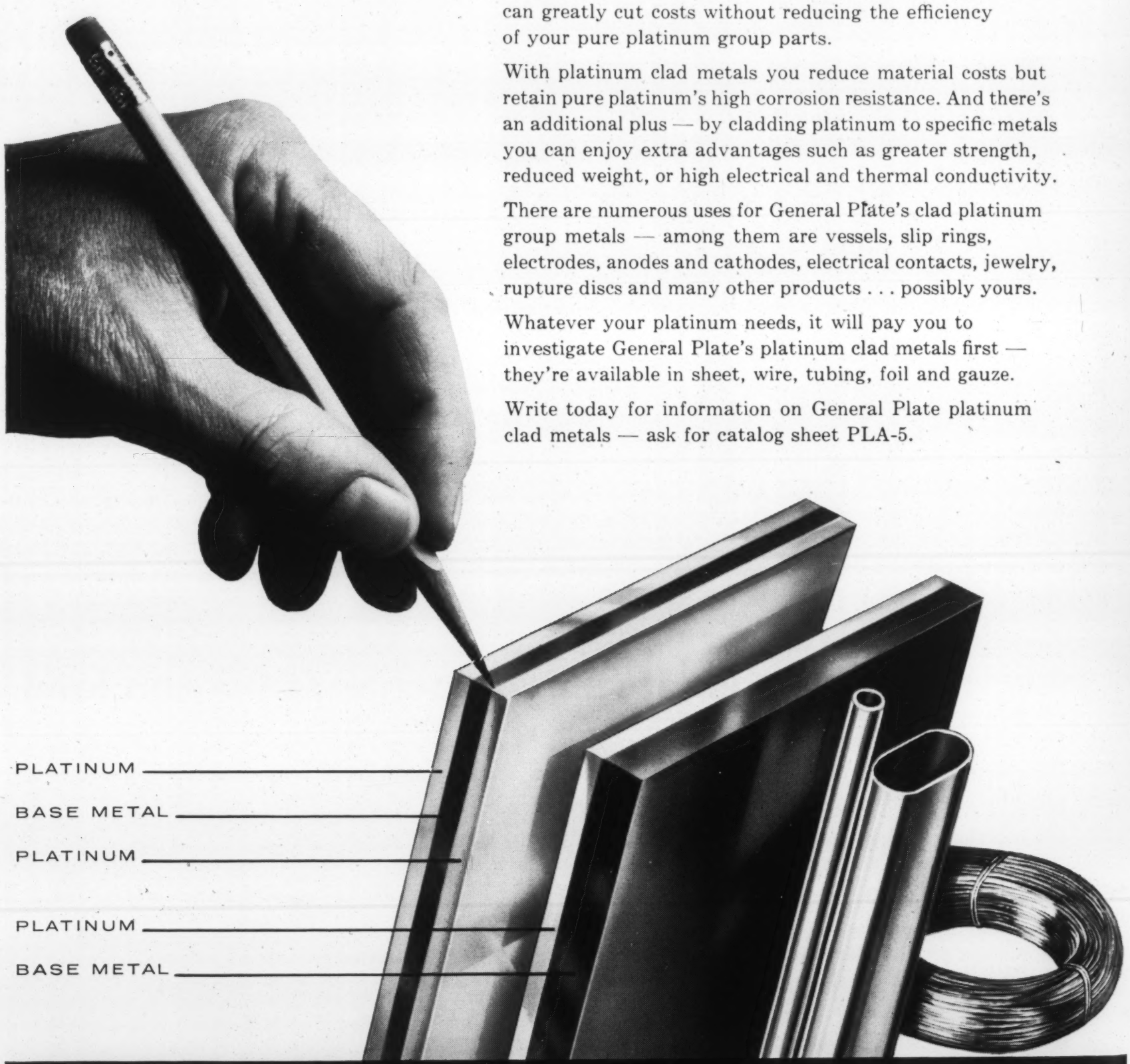
Chemigum, Plioflex, Pliolite, Pliovic–T. M.'s The Goodyear Tire & Rubber Company, Akron, Ohio

CHEMIGUM • PLIOFLEX • PLIOLITE • PLIOVIC • WING-CHEMICALS

High Polymer Resins, Rubbers, Latices and Related Chemicals for the Process Industries

Two metals are often better than one and **General Plate** Clad Platinum Group Metals* are a case in point . . .



By using General Plate's clad platinum group metals you can greatly cut costs without reducing the efficiency of your pure platinum group parts.

With platinum clad metals you reduce material costs but retain pure platinum's high corrosion resistance. And there's an additional plus — by cladding platinum to specific metals you can enjoy extra advantages such as greater strength, reduced weight, or high electrical and thermal conductivity.

There are numerous uses for General Plate's clad platinum group metals — among them are vessels, slip rings, electrodes, anodes and cathodes, electrical contacts, jewelry, rupture discs and many other products . . . possibly yours.

Whatever your platinum needs, it will pay you to investigate General Plate's platinum clad metals first — they're available in sheet, wire, tubing, foil and gauze.

Write today for information on General Plate platinum clad metals — ask for catalog sheet PLA-5.

* Platinum group metals include platinum, iridium, osmium, palladium, rhodium, and ruthenium.

METALS & CONTROLS CORPORATION

General Plate Division

1612 Forest Street, Attleboro, Mass.

FIELD OFFICES: NEW YORK, CHICAGO, DETROIT, MILWAUKEE, LOS ANGELES

You can profit by using General Plate Clad Metals.

For more information, turn to Reader Service card, circle No. 464

For more information, circle No. 545

CALL CRUCIBLE FOR CONSISTENTLY UNIFORM STAINLESS STRIP

From coil to coil and heat to heat, you can rely on the uniformity of Crucible Stainless steel strip—in flatness, in finish, and in metallurgical quality. And Crucible's full integration from raw material to final delivery is your assurance of prompt, dependable service as well. For these two reasons, it pays to call Crucible whenever you need stainless strip. *Crucible Steel Company of America, The Oliver Building, Mellon Square, Pittsburgh 22, Pa.*

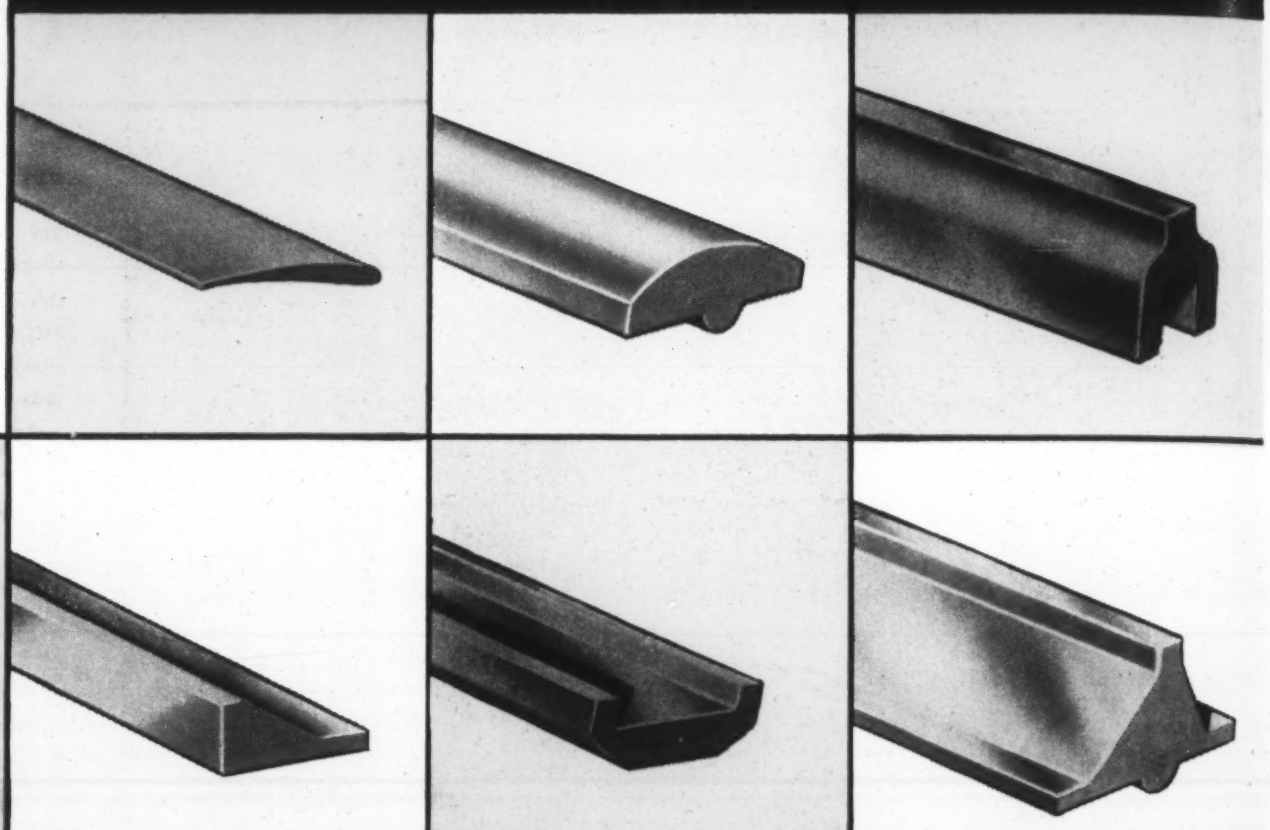
CRUCIBLE first name in special purpose steels

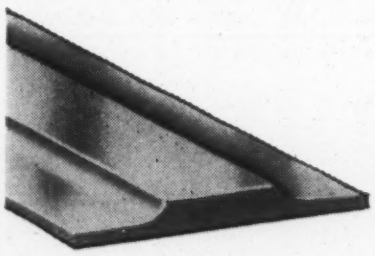
Crucible Steel Company of America

Canadian Distributor — Railway & Power Engineering Corp., Ltd.

CONTOUR ROLLING

Close Tolerances That Require No Finishing



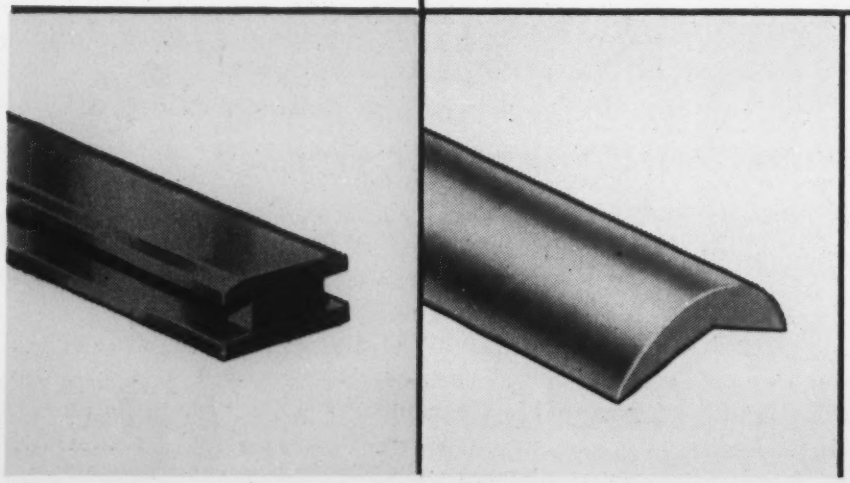


MAKEPEACE unique contour rolling process produces shapes held to tolerances as close as ± .001 of an inch.

Intricate angles of radii can be rolled into rod, wire, tubing and sheet.

MAKEPEACE unique contour rolling produces formed stock with excellent physicals and a fine finish that does not require a final finishing operation.

Send for the MAKEPEACE mill products booklet. It contains much information of value covering a wide range of Form Rolled Stock.



MAKEPEACE FORM ROLLED STOCK

D. E. MAKEPEACE COMPANY
Division of Union Plate and Wire Co.
ATTLEBORO, MASS.

ENGELHARD INDUSTRIES

For more information, turn to Reader Service card, circle No. 522

Tool Steel Topics

BETHLEHEM STEEL

In the Pacific Coast Bethlehem products are sold by Bethlehem Pacific Coast Steel Corporation

BETHLEHEM STEEL COMPANY, BETHLEHEM, PA.

Export Distributor: Bethlehem Steel Export Corporation

Forming die made from Brake Die steel machines easily, wears longer, cuts costs

It's obviously no job for an ordinary tool steel. The big die made of Bethlehem Brake Die tool steel comes down with a whoo-o-o-m-p, quickly forming the flange for a casket lid, made from 18-gage sheet steel. The action takes place at Boyertown Burial Casket Co., Boyertown, Pa.

"With the die formerly used," said one of Boyertown's engineers recently, "we obtained only average service because of relatively fast wear. Now that we've changed to Brake Die steel, we get much longer wear, and of course greater economy. The grade stands the gaff, and it machines beautifully."

Bethlehem Brake Die saves time in the shop because it comes in the heat-treated condition, ready for machining without further hardening. It has good wear-resistance, a high degree of toughness, and good resistance to impact. After heat-treatment by oil-quenching and tempering, Brake Die is straightened, stress-relief-annealed, then gag straightened. This is your assurance that it is not only straight, but will stay that way when machined to contour.

Brake Die can be used successfully for a wide variety of bending and forming applications. Your Bethlehem tool steel distributor will be pleased to supply full details. You'll find him very helpful, too.

BETHLEHEM TOOL STEEL ENGINEER SAYS:

Preheating Tool Steel? Here Are the Facts

Preheating tool steel before heating to the quenching temperature has long been a confusing subject. Some people advocate that every tool be preheated. Others insist it is not necessary to preheat any tools made of certain grades, supposedly because of the "superior built-in quality" of those steels. The truth lies somewhere between these extremes.

Generally, the need for preheating is based more on the size, shape and condition of each individual tool than on the grade of steel from which it is made.

Under the following conditions, preheating is definitely necessary:

1. Large tools should always be preheated regardless of grade, to avoid any possibility of cracking due to thermal stress. Generally, tools whose cross section is 6 in. or more in one direction, or whose length is more than four times the average section, should be considered "large" for this purpose.
2. Tools with drastic section changes (cross section area ratio of 2 to 1, or greater) should be preheated to avoid warping during heating, which otherwise would produce excessively distorted tools after heat-treatment.
3. Where tools are being heat-treated in equipment which does not provide a protective atmosphere, preheating is advantageous. By using a preheat it is possible to hold the heating time in the furnace to a minimum, avoiding excessive scale and decarburization.
4. If tools have been produced by any method of cold working, such as hobbing, shearing, punching, coining, etc., a preheat is necessary to avoid warping or cracking, unless a stress relief operation was used after the cold-work operation.

In addition to preheating under the conditions listed, many heat-treaters use a preheat as a matter of routine, more or less as a form of insurance. For like insurance, preheating also must be considered before troubles arise.

Where a competitive grade of tool steel is used "because it does not require preheating," you can be sure that the equivalent Bethlehem grade of tool steel can also be used successfully without a preheat on tools of the same size and shape.

For more information, turn to Reader Service card, circle No. 480

Where can this FLEXIBLE, clear, plastic tubing fit into your plans?

TYGON

✓ If you convey corrosive gases and liquids.

✓ If you convey liquid food products.

✓ If you require flexible lines with solution visibility.

Chemically-resistant, non-toxic, supple as a fly line, Tygon clear flexible plastic tubing is the ideal medium for those tough-to-solve piping problems.

Possessing a flex life ten to twelve times that of rubber, free of aging characteristics, Tygon serves equally well as a permanent component in machines or as quickly assembled and disassembled, temporary or permanent plant piping.

QUICK FACTS

Six standard formulations to meet a wide range of requirements.

Special formulations for unusual needs.

More than 50 standard sizes ranging from 1/16" to 3" ID.

Available if desired with outer braid reinforcement for pressures up to 300 psi.

THIS FREE BOOK TELLS THE COMPLETE STORY

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The U. S. Stoneware Co.,
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Ask for Bulletin T-97

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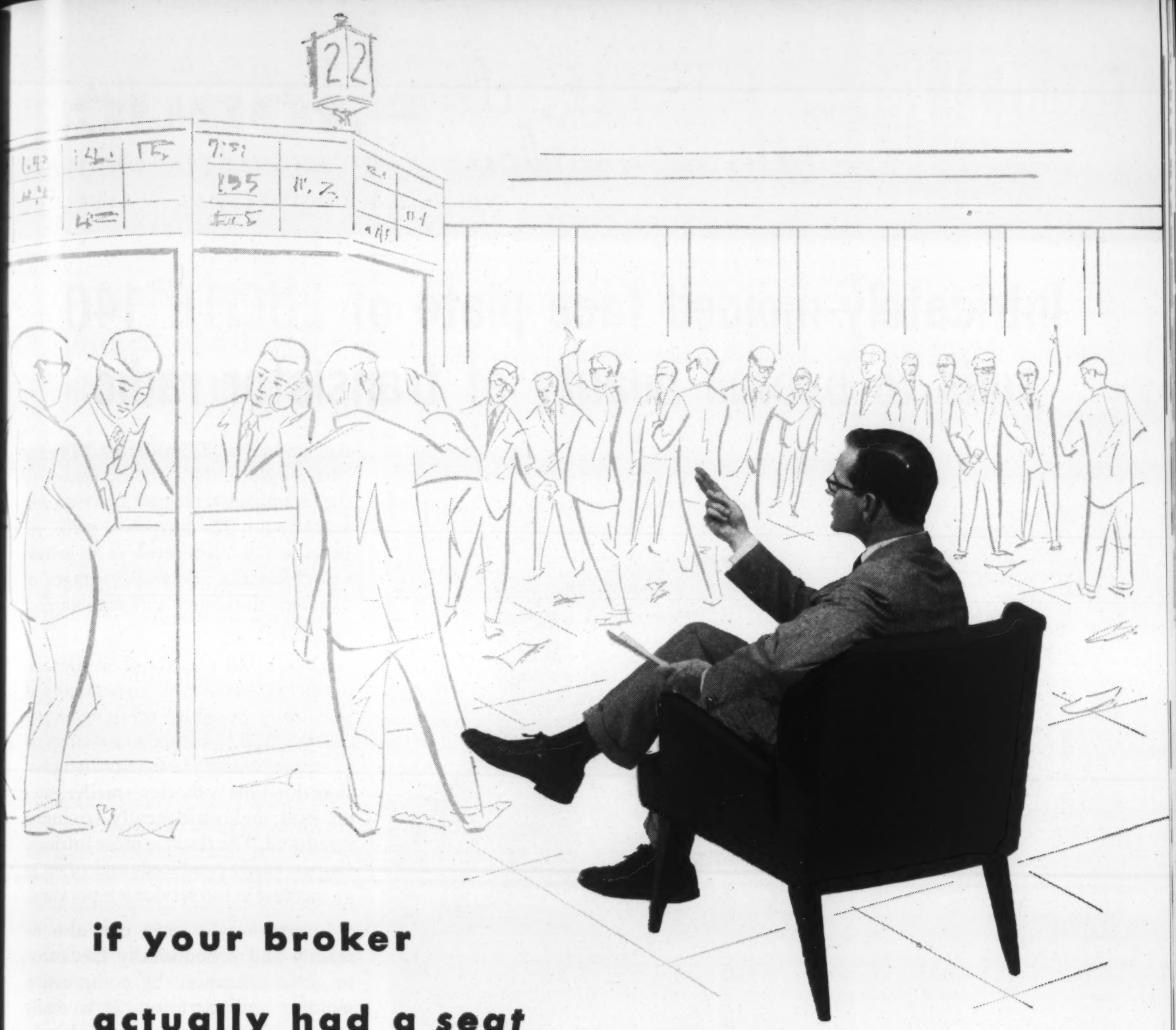

if your broker actually had a *seat* on the exchange *he'd demand . . .*

URETHANE FOAMS
based on
NATIONAL NACCONATES®

National Aniline does not make urethanes but is a major producer of diisocyanates—Nacconates®—basic component of all urethane formulations.

Urethanes are the newest and most versatile material used for comfort cushioning.

But their versatility just begins there! Controlled resilience makes these new foams equally useful for impact absorption in safety and packaging applications. And they provide excellent thermal insulation as well.

Light but tough, urethane foams have high tensile strength and good resistance to abrasion, chemicals and aging. They are vermin-proof, mildew-proof and can be washed or dry cleaned.

Urethane foams can be foamed in place; pre-molded to required shapes; cut, sawed, nailed, hog-ringed, sewn, draped, quilted or laminated to other materials. Low in first cost, they're economical to fabricate, too.

There is a good chance that urethanes offer opportunities for product improvement and development in your business. If you will briefly outline your potential interest, we will be glad to send current data on urethanes.

NATIONAL ANILINE DIVISION
ALLIED CHEMICAL & DYE CORPORATION

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DU PONT
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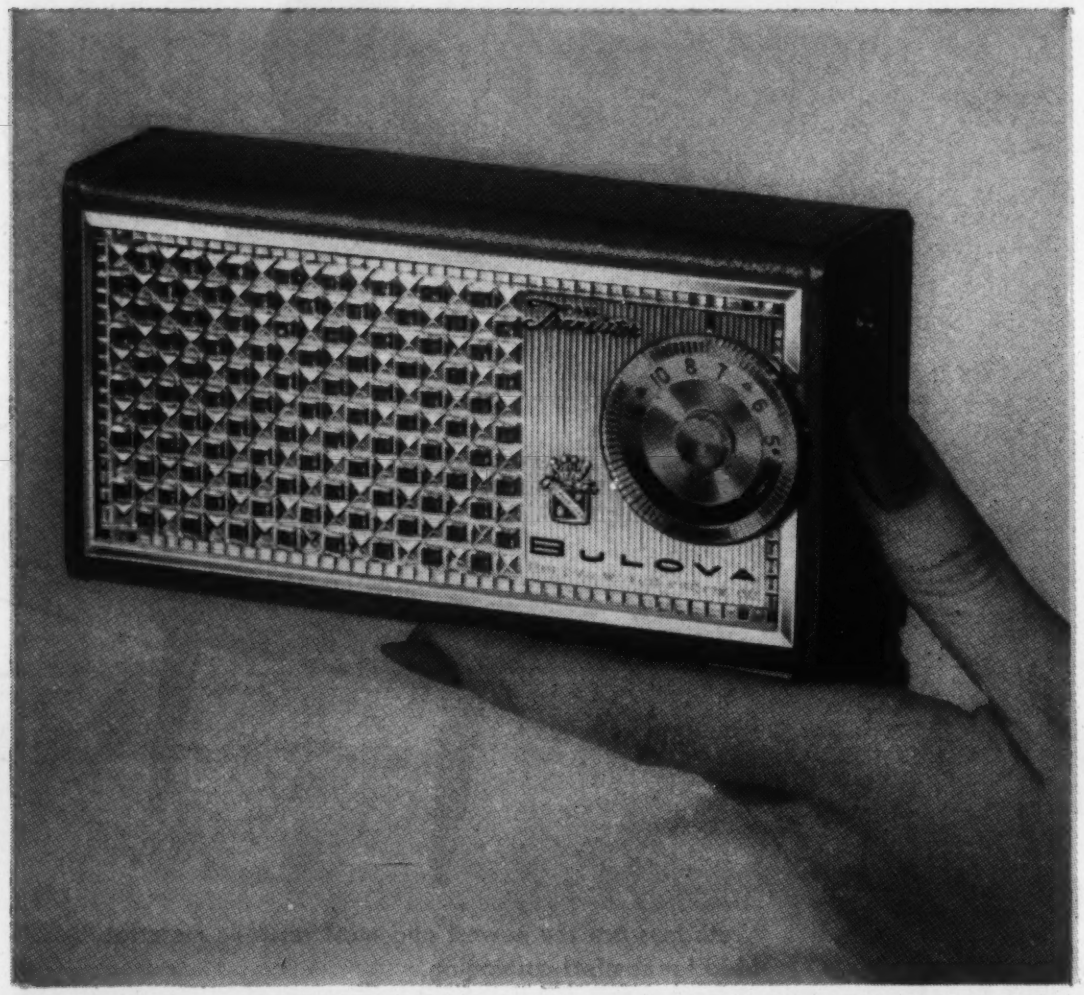
BETTER THINGS FOR BETTER LIVING ... THROUGH CHEMISTRY

PRODUCT

LATEST PROPERTY AND APPLICATION DATA ON THESE VERSATILE ENGINEERING MATERIALS

Intricately-molded face plate of LUCITE® 140 adds to overall beauty of transistor radio



REVERSE-SURFACE decorated face plate of transistor radio is typical of the intricate, yet durable, molded pieces possible with improved formulation of Du Pont LUCITE 140 acrylic resin. (The above face plate is molded and decorated by Kent Plastics, Evansville, Indiana, for Bulova Watch Company, Flushing, New York.)

An improved formulation, LUCITE 140, is behind the intricate beauty of the face plate on the new Bulova transistor radio. The attractive piece, reverse-surface decorated in a golden color, has the added advantages of excellent durability and high impact strength.

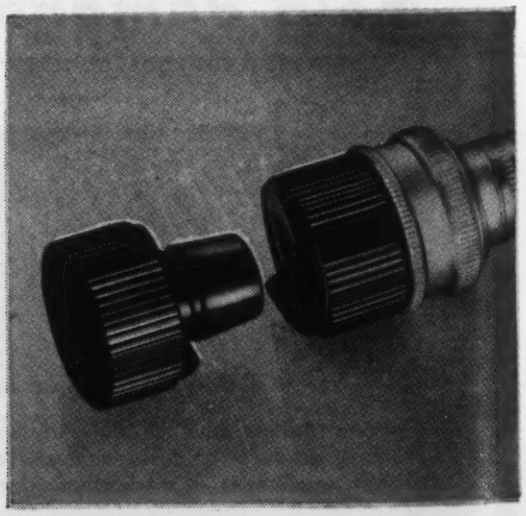
LUCITE 140 permits molding temperatures considerably higher than was previously possible, resulting in increased fluidity during processing and increased stability in the finished part. Injection time is shorter, smaller gates are used, and consequently, trimming is reduced. The result is more intricate shapes, easily produced, and often at an increase in top service temperature.

LUCITE acrylic resin can also be readily and economically fabricated to close tolerances by compression molding and extrusion. It is easily formed with conventional woodworking tools, much like wood or metal.

If you would like more information on this outstanding material, just mail the coupon on the next page.

"PERMA-JET" showerhead case and major operating parts of Du Pont ZYTEL are durable and heat-resistant. ZYTEL resists chemicals and corrosion, prevents clogging, keeps water rust-free. Water distribution is even, force of spray can be easily adjusted as desired. (Made by Webb Industries, Bay Village, Ohio.)

AIRCRAFT ANTENNA insulator block of a Du Pont TEFLON tetrafluoroethylene resin isolates antenna from metal base. High-density, stress-free block withstands air flow strains and minimizes dimensional change created by temperature extremes. (Mfgd. by John L. Doré Co., Houston, Texas.)



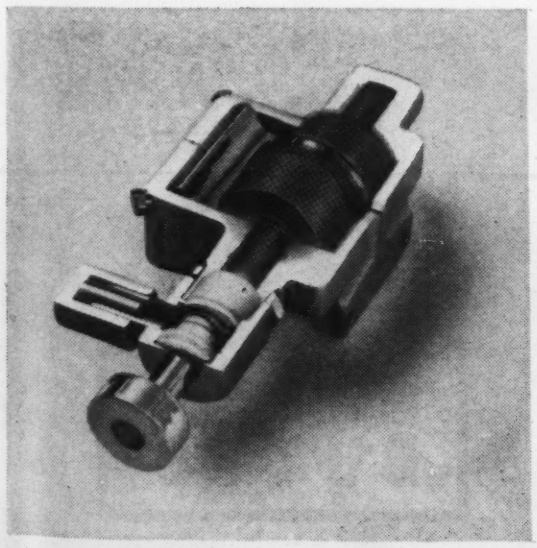
BLACK ZYTEL 105-BK10 is used for this garden hose coupler which connects with a simple push, twist to disconnect. The rugged coupling survives shock and abrasion. It will not corrode, even in the presence of garden chemicals. (Molded by The Ark Inc., for Stile Craft Mfg. Co., both of St. Louis, Mo.)

ENGINEERING NEWS

ZYTEL® TEFLON® LUCITE®

Optically correct lenses of LUCITE® are light, durable

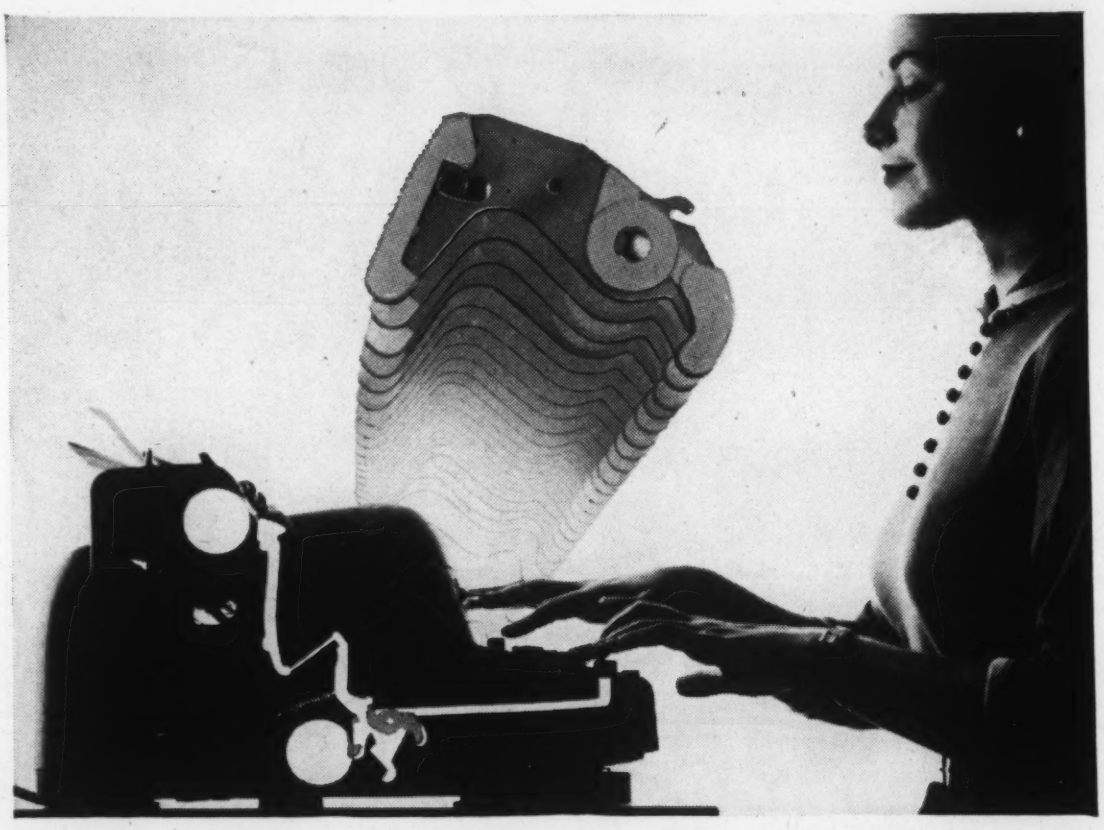
Lenses of LUCITE possess optical properties comparable to those of the finest glass, including the ability to transmit about 92% of the light striking their surfaces. LUCITE has several additional advantages . . . weighs only one-third as much as glass and has outstanding dimensional stability, impact strength and shatter resistance.



CHEMICAL PUMP uses three forms of TEFLON resins:—impeller and bearings are made of a glass-filled TEFLON resin; liquid packing of TEFLON 30 aqueous dispersion is used in the adjustable stuffing box; fluid retainer ring and adapter (white) are machined from extruded TEFLON 1 or 5. TEFLON resins have practically universal chemical inertness and withstand heat to 500°F. (Pump by ECO Engineering Co., Newark, New Jersey.)

For more information, circle No. 361

Mechanical parts of ZYTEL® nylon resin reduce wear and noise at critical points



LETTER CAMS in IBM electric typewriter throw the type bar forward by contacting power roller when typist presses key. In these accurate nylon-to-metal moldings, ZYTEL reduces wear on roller, deadens noise, resists abrasion and impact. (Made by International Business Machines Corp., Electric Typewriter Division, Kingston, New York.)

The letter cams in the IBM electric typewriter combine the stiffness and inertia of a steel body with the operational advantages of ZYTEL nylon resin:—The smooth, hard serrations at the power end of the letter cam produce minimum wear on the rubber-covered roller, while at the activating end of the cam, ZYTEL resists abrasion and impact; deadens noise. No lubrication is required, and maintenance problems are greatly reduced.

ZYTEL nylon resin is often molded to other materials. Metal shafts may be imbedded in gears of ZYTEL, and electrical contacts may be molded directly into hardware such as plugs and coil forms. Strong inserts can be made even in thin walls. Components of ZYTEL are extremely tough and light in weight. They are resilient, heat-resistant and durable.

Send the coupon for more information on the strong, basic engineering materials, Du Pont ZYTEL nylon resin.

SEND FOR INFORMATION

For additional property and application data on LUCITE® acrylic resin, TEFLON® tetrafluoroethylene resins and ZYTEL® nylon resin, mail coupon.

E. I. du Pont de Nemours & Co. (Inc.), Polychemicals Dept.
Room 1012, Du Pont Building, Wilmington 98, Delaware

Please send me more information on the Du Pont engineering materials checked: ☐ *ZYTEL;* ☐ *TEFLON;* ☐ *LUCITE. I am interested in evaluating these materials for:*

_____

Name _____

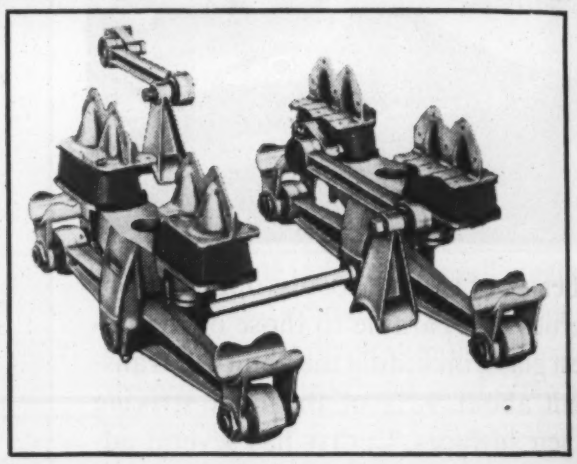
Company _____ *Position* _____

Street _____

City _____ *State* _____

Type of Business _____

In Canada: Du Pont Company of Canada (1956) Limited, P. O. Box 660, Montreal, Quebec



The unique design of the "load cushion" accounts for smooth, even rides in the full range of loads, empty to full. Enjay Butyl Rubber (in red) made it possible.

ENJAY BUTYL "LOAD CUSHION"

replaces steel springs in big Tractor Trailers

The "load cushion" is an important innovation in tandem suspension. Developed by the Hendrickson Mfg. Company, it is made of Enjay Butyl and replaces steel leaf springs. Utilizing the great strength and impact resistance of Enjay Butyl, the "load cushion" gives the ultimate in a soft, easy ride within the complete range of loading, from empty to full. Besides giving a smoother, steadier ride, it increases tire mileage, reduces weight and significantly reduces wear and tear on equipment.

Enjay Butyl has proved to be the answer to problems in many fields of industry. It may well be able to cut costs and improve the performance of *your* product. Low-priced and immediately available, Enjay Butyl may be obtained in non-staining grades for white and light-colored applications. Get all the facts by contacting the Enjay Company. Complete laboratory facilities and technical assistance are at your service.

ENJAY BUTYL

Enjay Butyl is the super-durable rubber with *outstanding* resistance to aging • abrasion • tear • chipping • cracking • ozone and corona • chemicals • gases • heat • cold • sunlight • moisture.

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Pioneer in Petrochemicals

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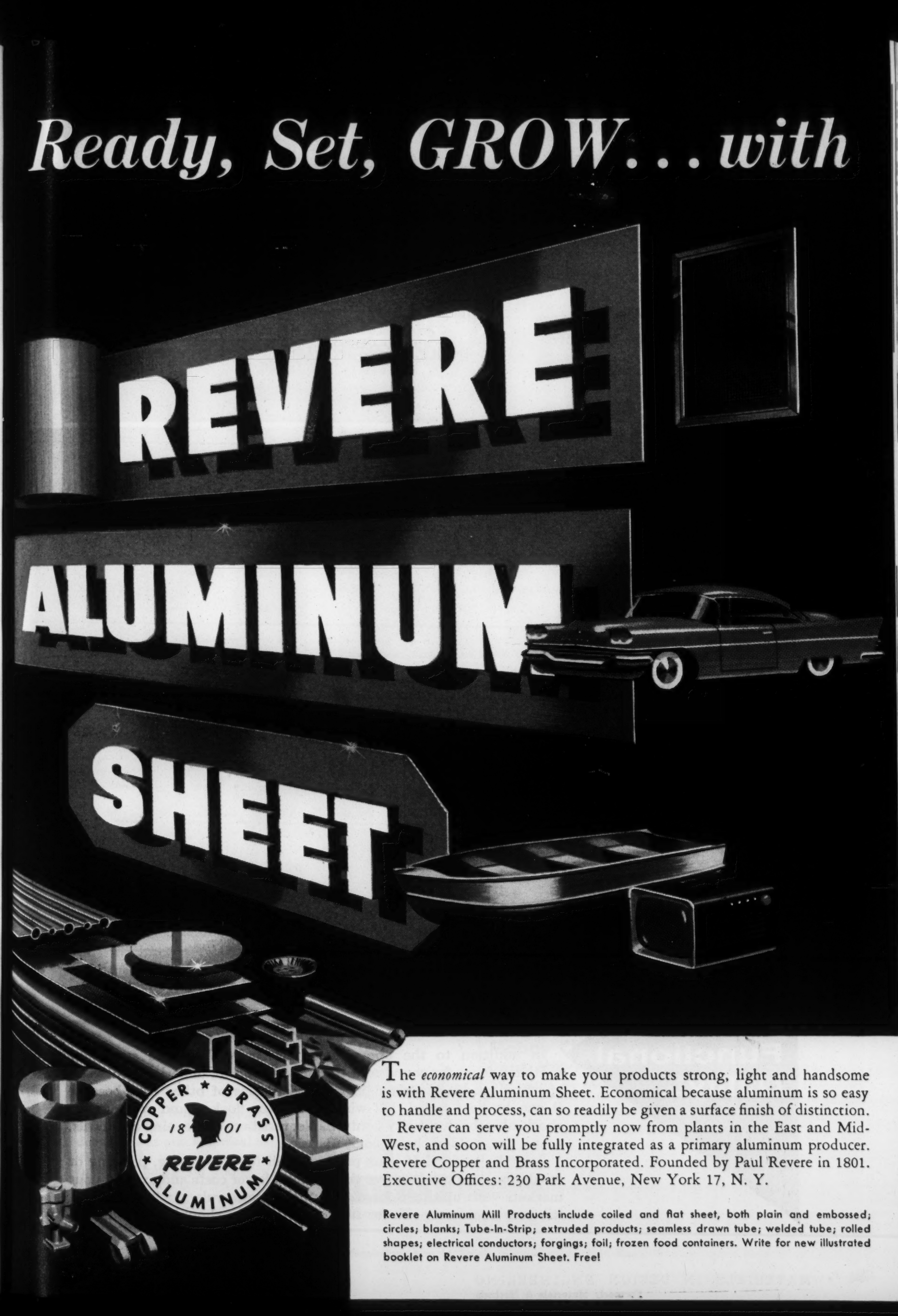


The *economical* way to make your products strong, light and handsome is with Revere Aluminum Sheet. Economical because aluminum is so easy to handle and process, can so readily be given a surface finish of distinction.

Revere can serve you promptly now from plants in the East and Mid-West, and soon will be fully integrated as a primary aluminum producer. Revere Copper and Brass Incorporated. Founded by Paul Revere in 1801. Executive Offices: 230 Park Avenue, New York 17, N. Y.

Revere Aluminum Mill Products include coiled and flat sheet, both plain and embossed; circles; blanks; Tube-In-Strip; extruded products; seamless drawn tube; welded tube; rolled shapes; electrical conductors; forgings; foil; frozen food containers. Write for new illustrated booklet on Revere Aluminum Sheet. Free!

Portion of urethane foam continuous process unit, F. Burkart Mfg. Co., St. Louis, Mo.

more URETHANE

In these ways:

For relaxable cushioning, soft to the touch, yet not bouncy.

As padding for bulkhead and doors, carpet underlay and seating.

Because of these advantages:

So tough it hog-rings to seating springs without backing support or fabric liners.

Elasticity, durability and structural strength unmatched by any other foam material.

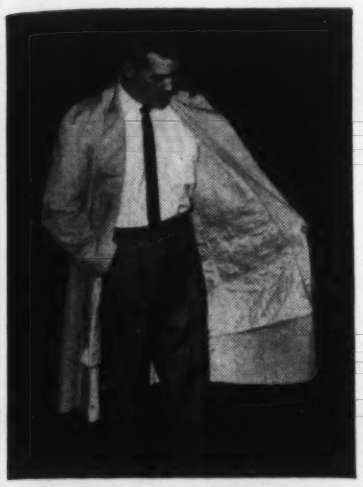
... Plus Functional Utility ...

In addition to the above uses, industry leaders are specifying urethane foam for sound and thermal insulation, underlay, footwear, sporting goods, household items, and dozens of other uses because it can be heat-sealed, hot-wire or die-cut, flocked and colored; it's shock-absorbent, density-controllable, resistant to cleaning chemicals, soaps, fire, mildew, heat, cold, abrasion.

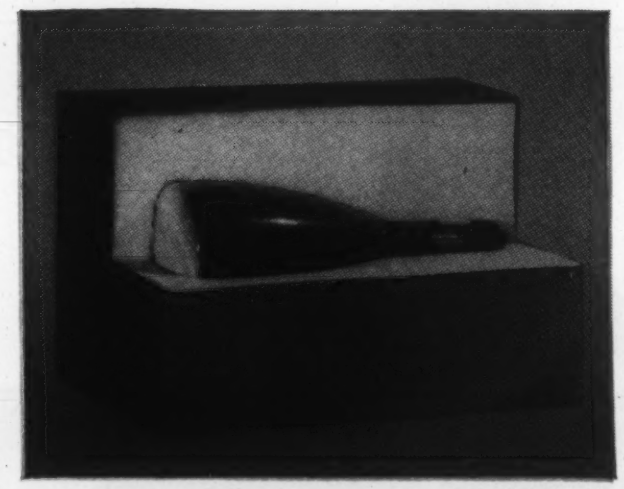
Join the leaders! If your products call for cushioning, padding or insulation, you can improve their design, lower costs and expand your markets with urethane foam. Remember sales rule #1: "If you wait 'til your customers ask for it, they're already shopping elsewhere."

and more

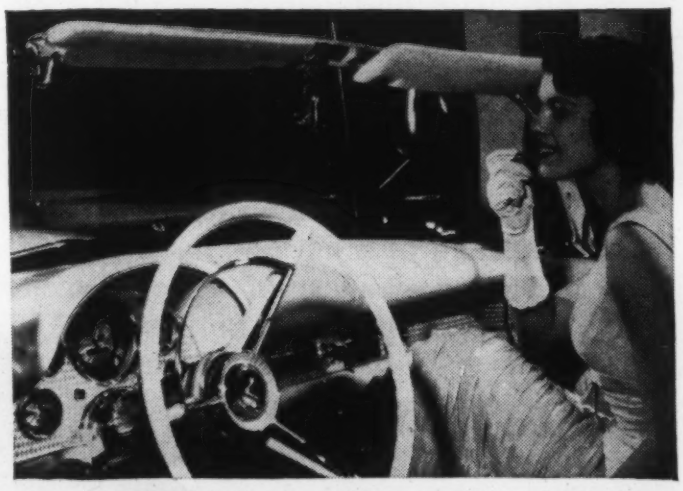
FOAM is being used



As supple, lightweight interlining for outerwear.



As economical protection for shipment and storage of precision equipment.



Molded safety dash panels and sunvisors for shock absorption and cushioning.

So easy to fabricate, it cuts with ordinary scissors or power-driven pattern cutters.

Feather-light, shock resistant —a wide range of densities, resiliencies and toughness.

Slices so thin it has the drape and feel of velvet . . . quilts to fabrics with standard equipment.

Mobay is the leading supplier of quality chemicals, product development and technical assistance, to manufacturers of urethane foams for industry. Write today for sources of supply and further information.

MOBAY

First in Urethane Chemistry

Mobay Chemical Company
Dept. MM-10
St. Louis 4, Mo.

Please send literature on flexible urethane foams ☐

Please have representative call on me ☐

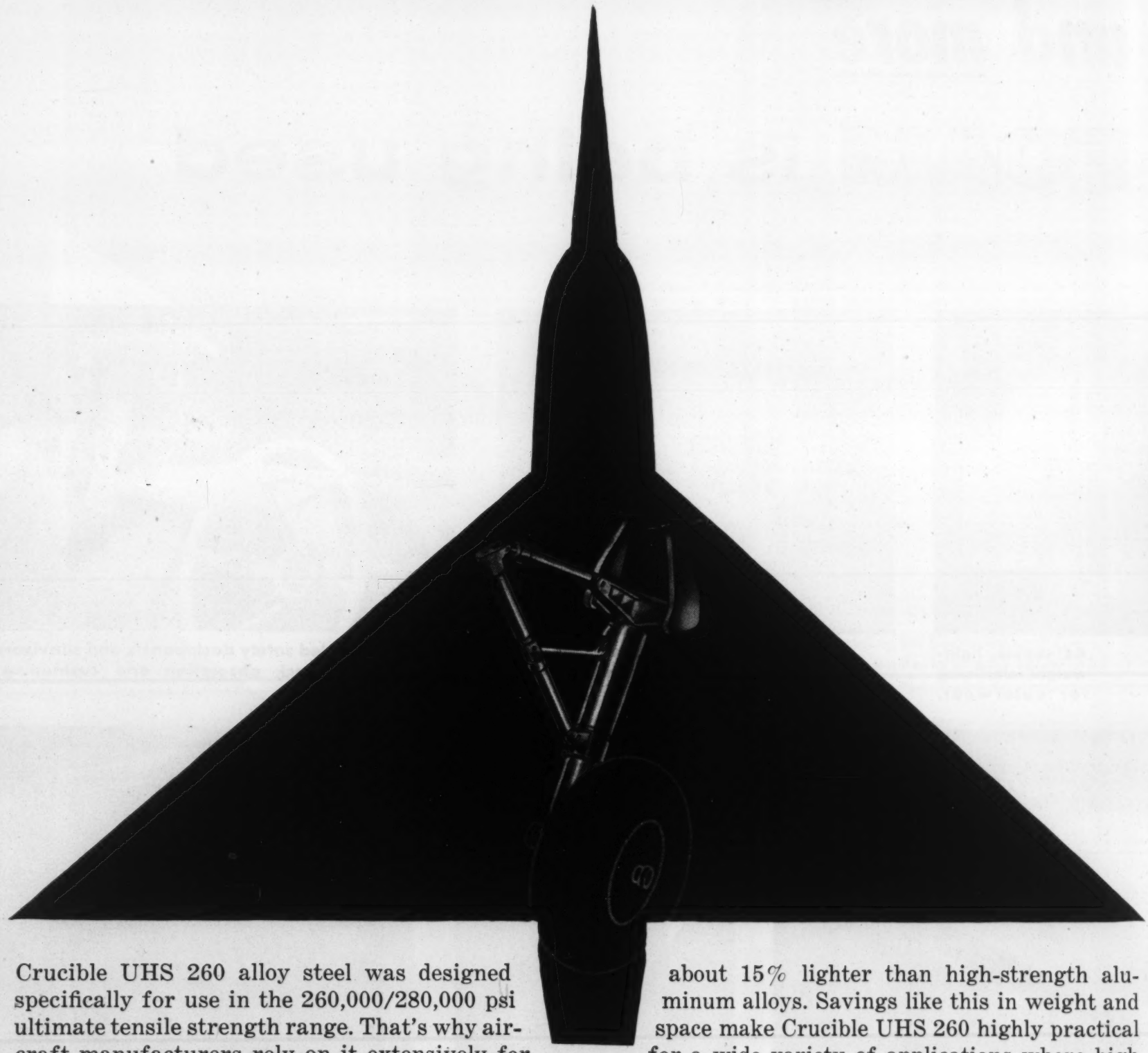
Name_____

Address_____

_____

For more information, turn to Reader Service card, circle No. 509

Crucible UHS 260 steel makes it 15% lighter



Crucible UHS 260 alloy steel was designed specifically for use in the 260,000/280,000 psi ultimate tensile strength range. That's why aircraft manufacturers rely on it extensively for aircraft parts such as landing gears. Now it's bringing definite advantages in applications where more properties other than just high strength are of primary concern.

Take, for example, parts where weight and cross-sectional dimensions must be limited. In such parts, Crucible UHS 260 pays off because under load it is about 15% lighter than high-strength aluminum alloys. Savings like this in weight and space make Crucible UHS 260 highly practical for a wide variety of applications where high strength, as such, is not the primary requirement.

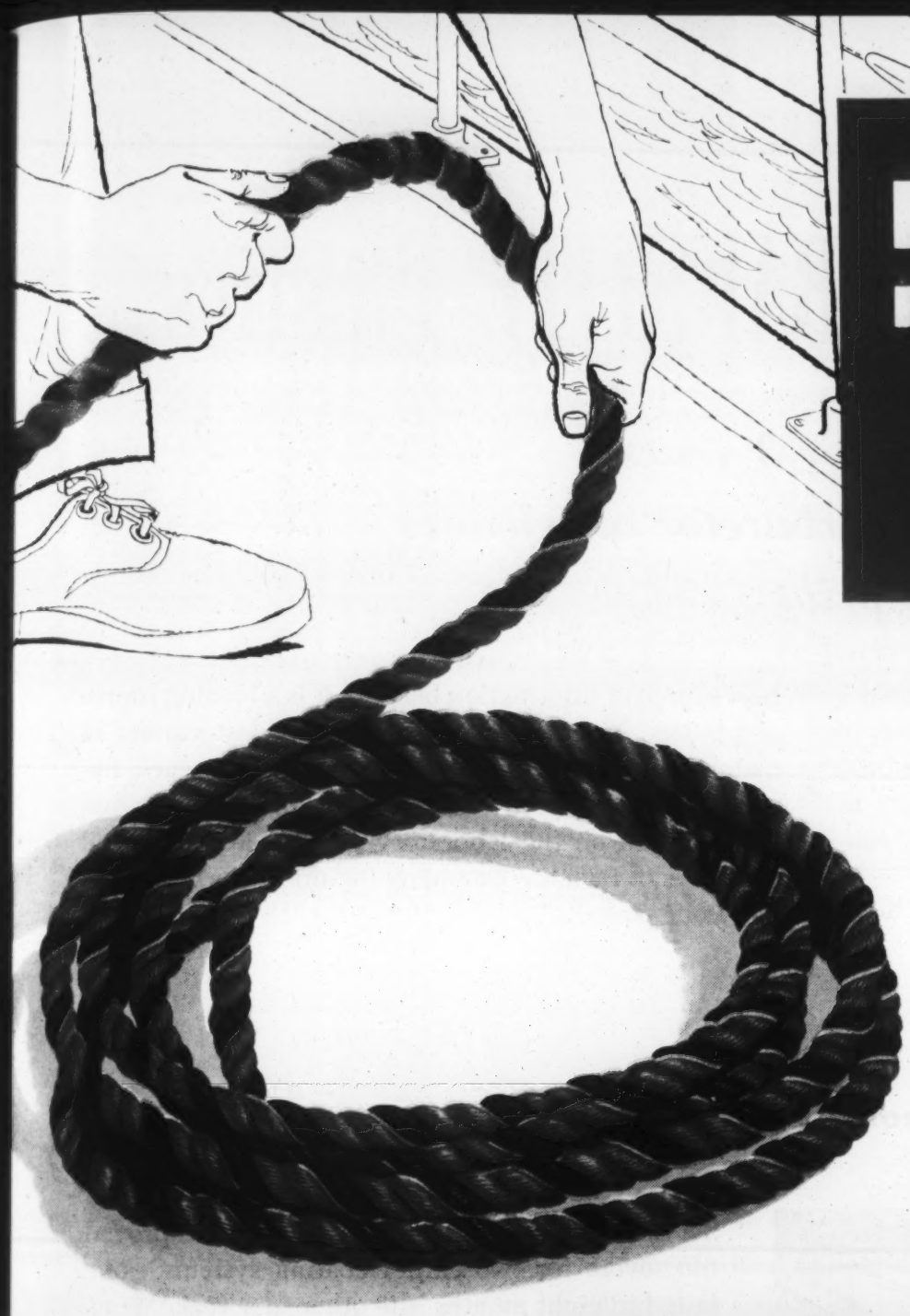
To check the other properties of Crucible UHS 260 alloy steel against your own particular problems, write for Data Sheet to *Crucible Steel Company of America, The Oliver Building, Mellon Square, Pittsburgh 22, Pa.*

CRUCIBLE first name in special purpose steels

Crucible Steel Company of America

For more information, turn to Reader Service card, circle No. 375

For more information, circle No. 528 ➤



MARLEX* 50 POLYETHYLENE

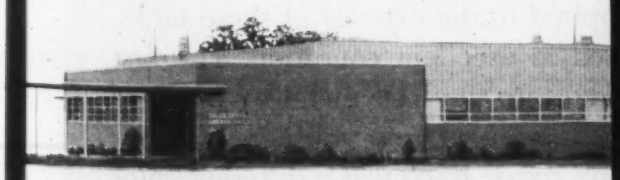
Makes Tough, Colorful Rope

Here is a brand new cordage material that is stimulating the interest of rope users everywhere! Filaments made from MARLEX 50 have a tensile strength varying from 50,000 to as high as 150,000 psi, according to diameter and draw-down.

MARLEX 50 polyethylene is a high-modulus material that produces filaments with excellent tenacity, superior resistance to moisture and chemicals, along with *low-temperature flexibility*. Applications are many and varied—from surgeons' sutures to tugboat hawsers.

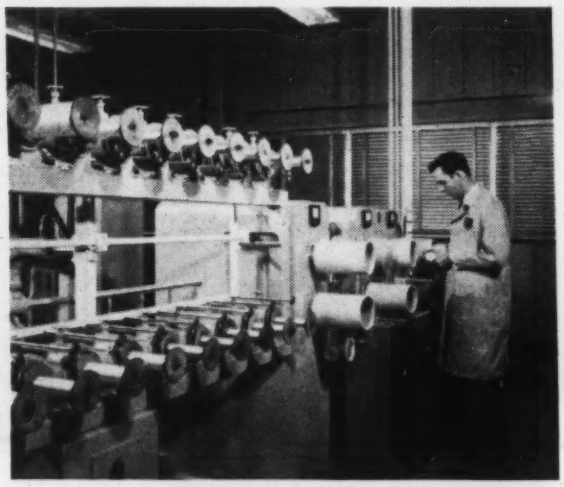
Don't delay . . . get in touch with your MARLEX sales representative today. Ask him to demonstrate for you the advantages of this amazing new low-cost material.

MARLEX SALES SERVICE LABORATORY



This new Sales Service Lab in Bartlesville is completely equipped with latest processing machinery and research apparatus. Phillips experienced technical service staff will assist you in developing new products and processes using MARLEX plastics. Please make arrangements through your MARLEX sales service representative.

Rope made from this revolutionary new polyethylene actually *floats . . . does not absorb water!* Thus, there is no swelling and consequent strand structure deformation when used in marine and other outdoor applications. Strength, endurance, heat resistance and light weight of MARLEX 50 rope will add to its popularity.



Filament spinning section at the Sales Service Lab, where MARLEX plastics specialists are constantly evaluating new manufacturing techniques and applications for MARLEX 50 filaments. They have discovered that filament elongation of this new plastic can be varied by orientation during processing from 5% to 30%, adding greatly to its versatility as a material.

*MARLEX is a trademark for the Phillips family of olefin polymers.

PLASTICS SALES DIVISION, PHILLIPS CHEMICAL COMPANY

A Subsidiary of Phillips Petroleum Company, Bartlesville, Oklahoma

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NEW ENGLAND	NEW YORK	AKRON	CHICAGO	WESTERN	SOUTHERN & FOREIGN
322 Waterman Avenue, East Providence 14, R. I. GEneva 4-7600	80 Broadway, Suite 4300 New York 5, N. Y. Digby 4-3480	318 Water Street, Akron 8, Ohio FRanklin 6-4126	111 S. York Street, Elmhurst, Ill. TErrace 4-6600	330 Security Bldg., Pasadena, Calif. RYan 1-6997	Adams Building, Bartlesville, Oklahoma Bartlesville 6600, Ext. 8108

Designing with BAKELITE Plastics
BRAND

- ***Coating protecting tanks for 3 years***
- ***Rugged plastic part for carburetor air cleaner***
- ***Plastic credit cards that print***

Keep informed about plastics and you'll find them a source of new design ideas. Besides the great variety of plastics already available, new products are constantly appearing. One of them may have exactly the set of properties you have been looking for, and at a considerable saving.

Keep in touch with Bakelite Company. It is your best source of information because it is a leading source of plastics. You can select from the widest variety of materials in the field – phenolics, vinyls, styrenes, impact styrenes, polyethylenes, epoxies, and silicones. And you can call on the laboratory services and technical resources of Bakelite Company for aid in working them into your plans.

1 Vinyl-based coating protects ammonia tanks three times longer

Service conditions surrounding these tanks proved too severe for two earlier coating systems – one failed in eight months, the other in a year. Measuring 10′ 6″ in diameter and 53′ long, the tanks hold caustic solution, and are located in a plant manufacturing 45 million lbs. of petrol-cracking catalyst annually. Vapors in the area contain sulfate salts and intermittent sulfuric acid spray.

Three years ago, a coating system made by Amercoat Corp. based on BAKELITE Brand Vinyl Resins was applied to the exterior of these tanks. It has remained in excellent condition. The first coat was worked into the bare metal by brush to obtain good adhesion. Three subsequent coats were applied by spray. Each was a different color to insure complete coverage. Total thickness was six to eight mils. Maintenance has been at a minimum.

A variety of coatings are formulated from BAKELITE Vinyl Resins and used widely in both industrial and consumer applications. For a complete description of these materials, write Dept. **AV-108.**

2 C-11 Plastic pre-cleaner withstands engine oil, heat, dirt

More than 75 percent of the dirt that would normally enter the oil-washed air cleaner on tractor engines is removed by this collector pre-cleaner made by Minnesota Plastics Corporation for Donaldson Company, Inc., St. Paul, Minn. It is also designed to serve as an air stack cap, preventing leaves, twigs, and chaff from entering, and forms a rain shield that keeps water out of the center tube intake. Molded of BAKELITE Brand C-11 Plastic, this collector pre-cleaner has a high heat distortion point, and stands up under the working temperatures generated by tractor engines. Since C-11 Plastic is transparent, the pre-cleaner shows when it has collected excess dirt, and is readily removed and washed.

BAKELITE C-11 Plastic is an acrylonitrile-styrene copolymer. It has good resistance to impact and exceptional resistance to chemicals, including foods. It offers a wide choice of color, and molds to a smooth, glossy finish. These properties have led to the wide use of C-11 in packaging as well as for machine parts like this collector pre-cleaner. For more details on C-11 Plastic, write Dept. **AW-108.**

3 Credit card, charge plate, and ad on one vinyl rigid sheet

This wallet-sized plastic card can tell you a lot about the design features of BAKELITE Brand Rigid Vinyl Sheets. The color printing, in perfect register, makes it an effective ad and proves its dimensional stability. The three-dimensional lettering shows how well these sheets can be formed to fine details. And toughness is demonstrated in the card's ability to stamp its imprint on invoices, as well as to take frequent handling without damage.

BAKELITE Rigid Vinyl Sheets come in several stock sizes and finishes, and a variety of colors, as well as clear transparent, translucent, or opaque. They can be formed into three-dimensional shapes to fill a wide range of design requirements. To learn more about them, write Dept. **AX-108.**

TYPICAL PROPERTIES OF "BAKELITE" RIGID VINYL SHEETS

Heat distortion temp. at 264 psi. Fiber stress, deg. C. (D648-45T)	64 avg.
Flammability (D568-43)	self-extinguishing
Tensile strength, psi (D638-49T)	7700 avg.
Flexural strength, psi (D790-49T)	12,600 avg.
Modulus of elasticity in flexure, psi (D790-49T)	430,000 avg.
Impact resistance (impactometer method) ft./sec. (WC-68-C-1/1) (corrected to .010 inch)	55 avg.
Specific gravity, 23/23 deg. C. (WC-1-M/1)	1.45 avg.
Dielectric strength (0.100 in. specimen) volts/mil Short time test in oil (D149-55T)	425 avg.
Volume resistivity, ohm-cm. (D257-54T)	10^{16} avg.

THERE'S MORE TO DESIGN WITH IN

BAKELITE

BRAND

PLASTICS

PHENOLICS
STYRENES
IMPACT STYRENES
VINYLS
EPOXIES
POLYETHYLENES
SILICONES

UNION CARBIDE

BAKELITE COMPANY, *Division of Union Carbide Corporation*, 30 East 42nd Street, New York 17, N. Y.

The terms BAKELITE and UNION CARBIDE are registered trademarks of UCC.

For more information, turn to Reader Service card, circle No. 525

For whatever you make . . .

N-A-X® HIGH-STRENGTH STEELS CONTRIBUTE STRENGTH WITH LIGHT WEIGHT

Hamlintainers — the versatile knock-down, pallet-type steel shop and shipping boxes built by Hamlin Metal Products Corp., Akron, Ohio — make still another profitable example of the adaptability of N-A-X HIGH-STRENGTH steels.

Developed in answer to Hamlin's own shop problems, *Hamlintainers* quickly proved themselves in the nation's leading automobile, aircraft and appliance manufacturing plants. On the job *Hamlintainers* must have strength to carry heavy fabricated parts and still be light enough for fast, easy plant handling and minimum return freight costs.

Like so many producers, Hamlin looked for and found these characteristics of strength with lightness in N-A-X HIGH-STRENGTH steels, along with other significant benefits.

Check These Important Advantages for Your Job: N-A-X HIGH-STRENGTH steels—both N-A-X HIGH-TENSILE and N-A-X FINEGRAIN—compared with carbon steel, are 50% stronger . . . have high fatigue life with great toughness . . . are cold formed readily into difficult stampings . . . are stable against aging . . . have greater resistance to abrasion . . . are readily welded by any process . . . offer greater paint adhesion . . . polish to a high luster at minimum cost.

Although N-A-X FINEGRAIN's resistance to normal atmospheric corrosion is twice that of carbon steel, N-A-X HIGH-TENSILE is recommended where resistance to extreme atmospheric corrosion is important.

For whatever you make, from steel boxes to boxcars, with N-A-X HIGH-STRENGTH steels you can design longer life, and/or less weight and economy into your products. Let us show you how.

N-A-X HIGH-STRENGTH STEELS

N-A-X Alloy Division, Dept. D-10

GREAT LAKES STEEL CORPORATION

Detroit 29, Michigan • Division of

NATIONAL STEEL CORPORATION

N-A-X Alloy Div., Dept. D-10
Great Lakes Steel Corp., Detroit 29, Mich.

☐ Please send me 12-page illustrated technical catalog on N-A-X HIGH-STRENGTH steels.

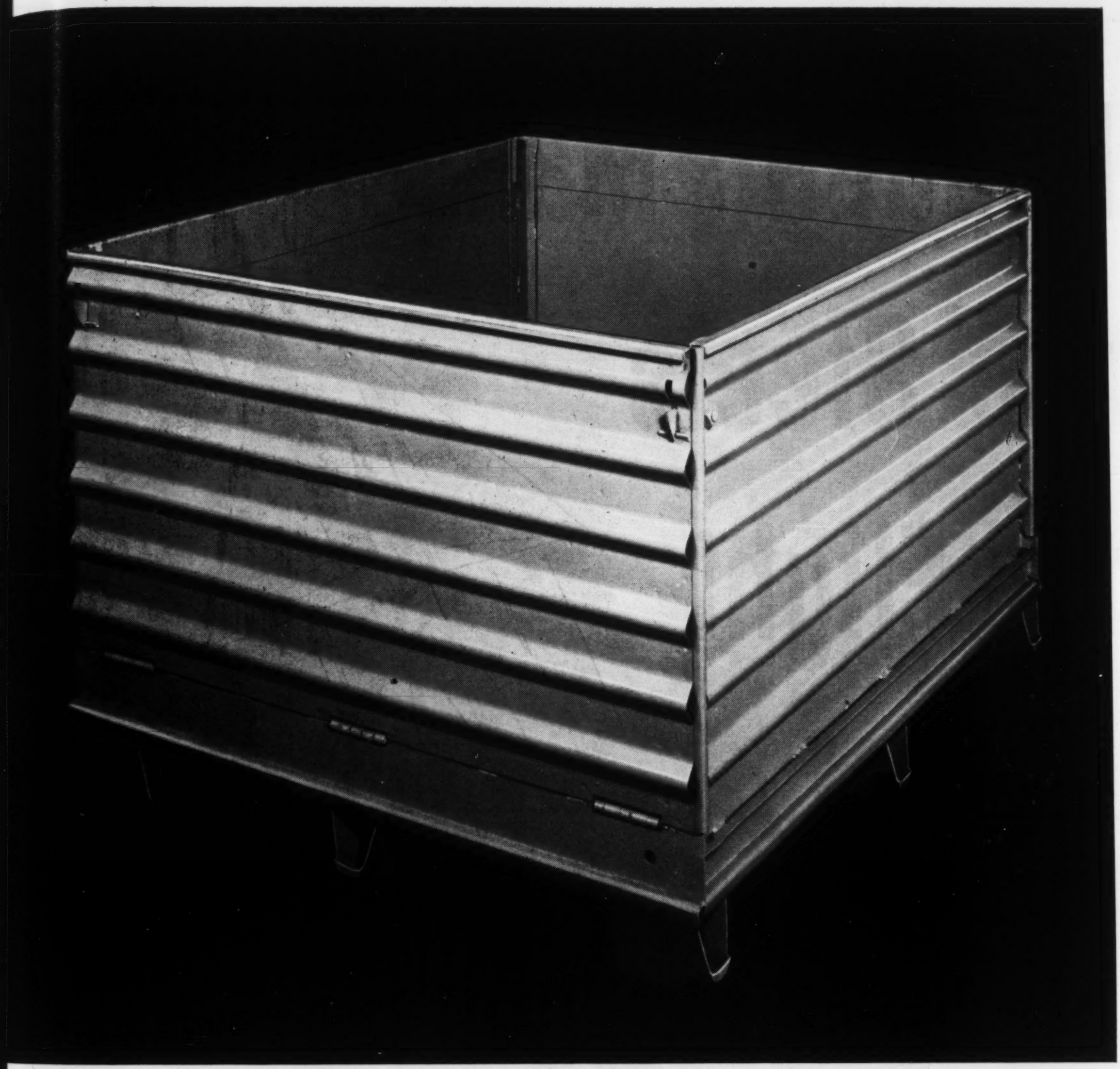
☐ Please have your representative contact me.

Name_____ Title_____

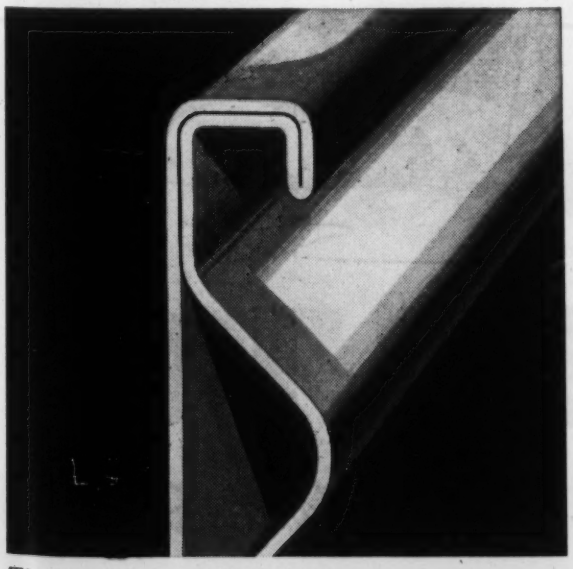
Company_____

Street_____

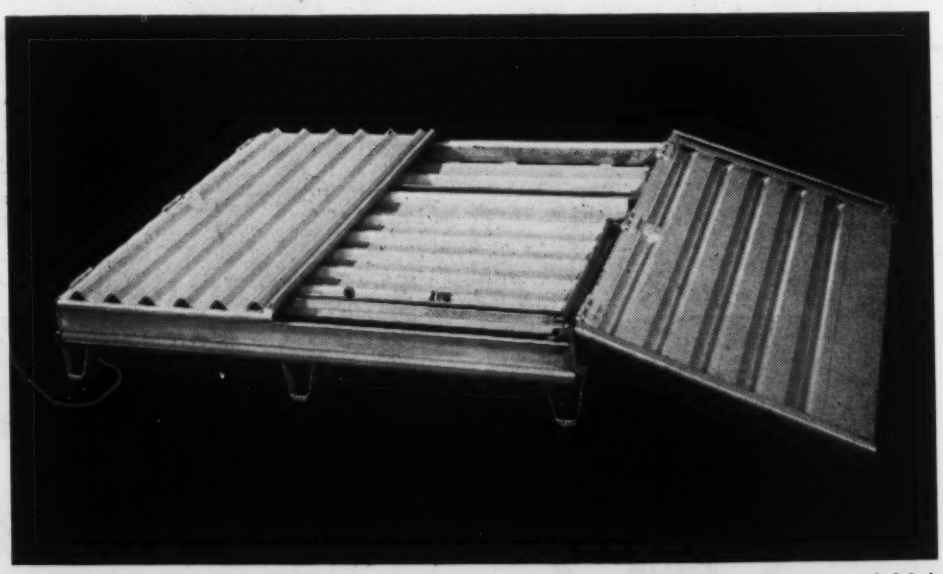
City_____ Zone_____ State_____



Hamlintainers *are the result of more than five years of intensive research, development and practical on-the-job testing. Thanks to* N-A-X HIGH-STRENGTH *steels,* Hamlintainers *are tight enough to hold rivets, strong enough to carry forgings and* light *enough for moving by any standard plant fork-lift truck.*



The great formability of N-A-X HIGH-STRENGTH *steels makes this design easy to produce. Rounded edges add strength, safety.*



In less than 20 seconds, one worker can set up a Hamlintainer, *or fold it flat for easy stacking when not in use. This important benefit continues to win new friends for* Hamlintainers *with manufacturers.*

For more information, turn to Reader Service card, circle No. 447

Republic Makes the Steels for Flight

REPUBLIC

REPUBLIC STEEL

World's Widest Range of Standard Steels

Republic Steel is the world's largest producer of aircraft steels. And include guided missiles in aircraft. They are fast becoming a sizable steel consumer.

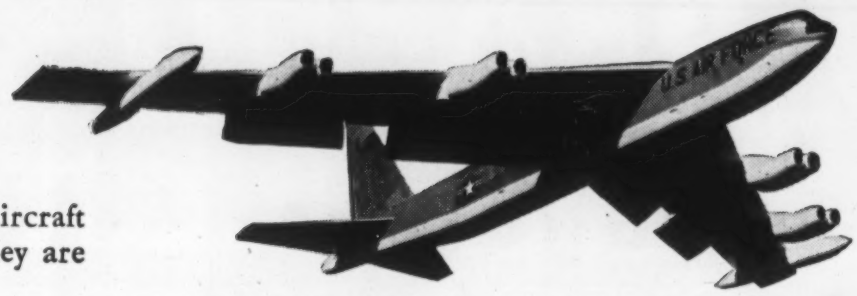
Steels furnished to the aircraft industry are as different as night and day. Requirements may individually call for strength, heat-resistance, corrosion-resistance, wear-resistance, high strength-to-weight ratio, ductility—or any combination of these factors.

One reason for Republic Steel's prominence in this field is that Republic *makes a wide variety of the steels required.* Another reason is its metallurgical service teams—field, mill and laboratory metallurgists with years of experience gained through helping hundreds of designers and manufacturers solve problems similar to yours.

Now that the sound barrier has been passed and the next goal in sight is the "thermal thicket," material selection becomes even more important. To date two materials, titanium alloys and stainless steel, best qualify to meet high skin temperatures resulting from aerodynamic heat. Republic produces both of these metals in billets, hot rolled and cold finished bars, plates, sheets, and strip.

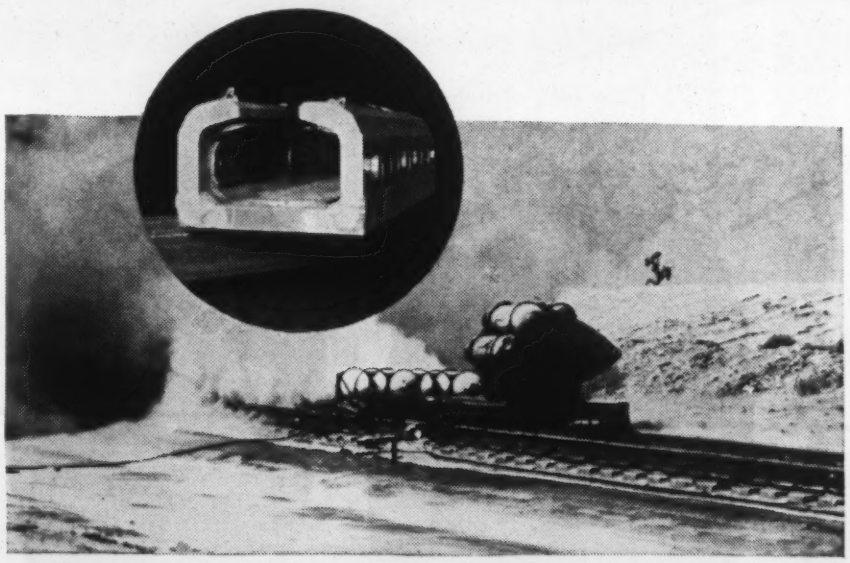
Republic Alloy Steels have played a prominent part in the development of operating and structural parts free from excess weight, yet tough and strong to withstand shock, impact, strain and vibration.

Our metallurgists and engineers are always available to work with your own personnel in using these Republic products to best advantage. The service is obligation-free and confidential. Send us the coupon if you would like metallurgical assistance.



TITANIUM IN THE BOEING B-52 saves 400 pounds in gross weight. Jet engine pods for this history-making, global bomber are fabricated by Bell Aircraft Corporation from titanium supplied by Republic and other producers. Titanium was selected for this application because of its lightness, strength, and corrosion-resistance. It offers the highest strength-to-weight ratio of construction metals. Titanium's extremely high corrosion-resistance makes it attractive for missile applications, such as fuel tanks. Nitric acid has little effect on titanium. It is immune to the corrosive action of salt water and sea air. Write for more facts.

ALLOY STEEL IN THE NORTH AMERICAN F-100 landing-gear struts provides strength, toughness, maximum resistance to fatigue. The struts are made by Bendix Product Division, Bendix Aviation Corporation. Exacting requirements for inner and outer cylinders resulted in the development of new grade of steel by Bendix and Republic metallurgists working in cooperation with North American engineers. This new steel, designated AMS 6427, was found ideal for application in the strength range of 220,000-240,000 psi. It maintains its great strength at wide temperature extremes. Republic metallurgists are available to help with your projects.



STAINLESS STEEL HELPS SPEED ROCKET SLED to world's record of 1560 miles an hour. The sled, designed and built by Convair Division of General Dynamics Corporation, is used in supersonic tests to evaluate the effect of rain erosion on aircraft and missile parts. The sled rides rails on slippers made of SAE 4130 Alloy Steel. Within each slipper (see photo inset) are stainless steel inserts, Type 321, of which Republic is a supplier. The inserts serve as a lubricant to reduce friction by shucking off metal particles at a temperature of 1500°F. The stainless inserts reduce friction so effectively that engineers no longer take it into account in calculations of sled performance.

STEEL

and Steel Products

REPUBLIC STEEL CORPORATION
DEPT. C-3689
3176 EAST 45TH STREET
CLEVELAND 27, OHIO

Please have a metallurgist call:
☐ Stainless ☐ Titanium ☐ Alloy

Send more information on these Republic products:
☐ Titanium ☐ ENDURO® Stainless Steel ☐ Alloy Steel

Name_____ Title_____

Company_____

Address_____

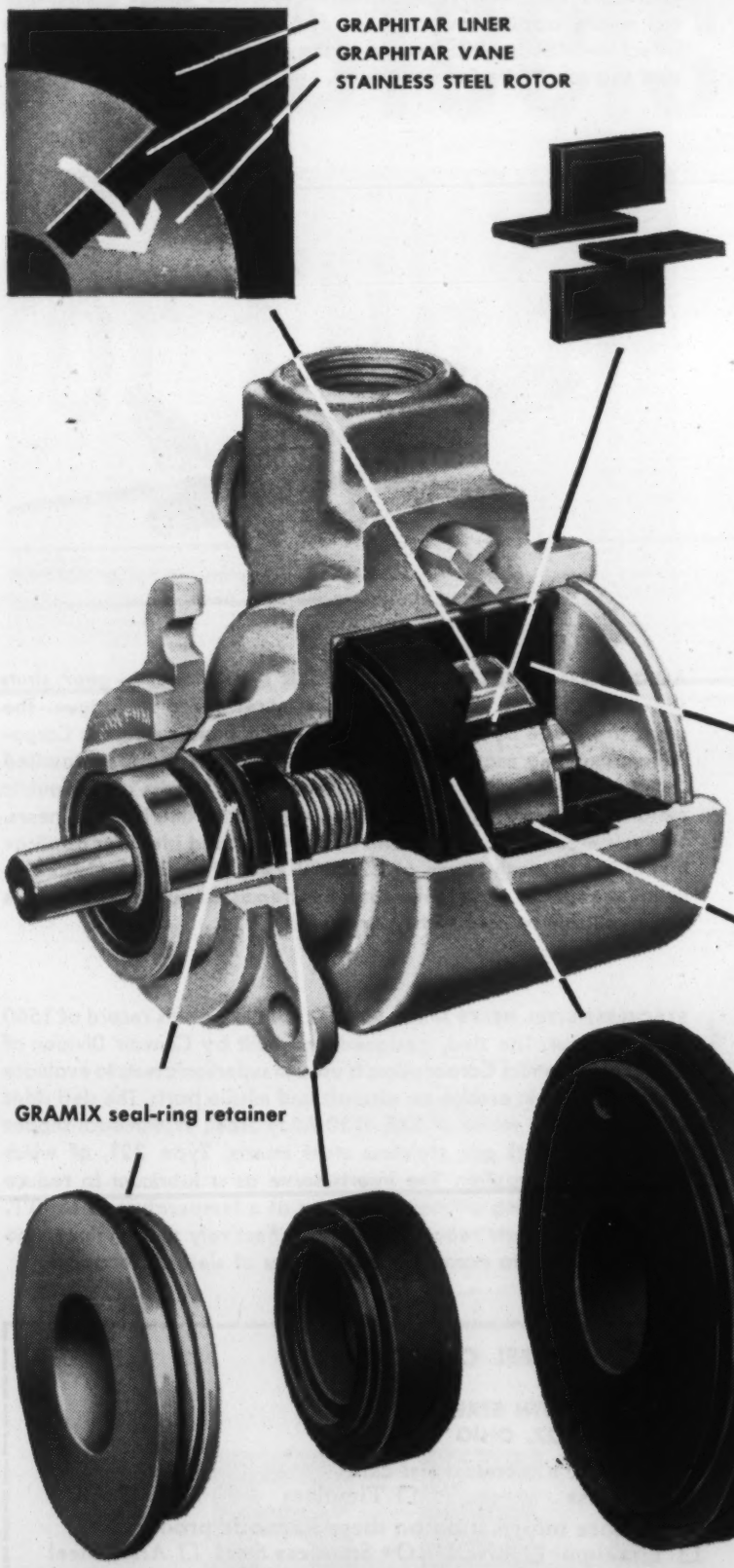
City_____ Zone____ State_____

For more information, turn to Reader Service card, circle No. 390

GRAPHITAR® running against GRAPHITAR

(CARBON-GRAPHITE)

gives PROCON PUMPS amazing performance in handling *ALL TYPES OF FLUIDS*



Mixing soft drinks . . . pumping chemicals, ethyglycol, ammonia . . . even pumping hot fats at the rate of 275 gallons an hour at pressures up to 300 psi, is the every-day work of the dependable little Procon pump, manufactured by the Procon Pump and Engineering Company of Detroit, Michigan. The liner, vanes, end-plate bearings and the seal ring of this versatile, high performance pump are made of GRAPHITAR. The four GRAPHITAR rotor-vanes run directly against a GRAPHITAR liner. By running GRAPHITAR against GRAPHITAR the self-lapping, self-lubricating, and astonishingly long-wearing qualities of GRAPHITAR are employed to full advantage . . . the Procon pump operates at close to 100% efficiency—indefinitely! In addition, the seal-ring retainer is made of GRAMIX®, a powdered metal product of the United States Graphite Company.

For more information on GRAPHITAR and its many applications, write for Engineering Bulletins No. 20 and 21.

The seal, end-plate bearings, liner and vanes are self-lubricating GRAPHITAR.

R-255-2

THE UNITED STATES GRAPHITE COMPANY

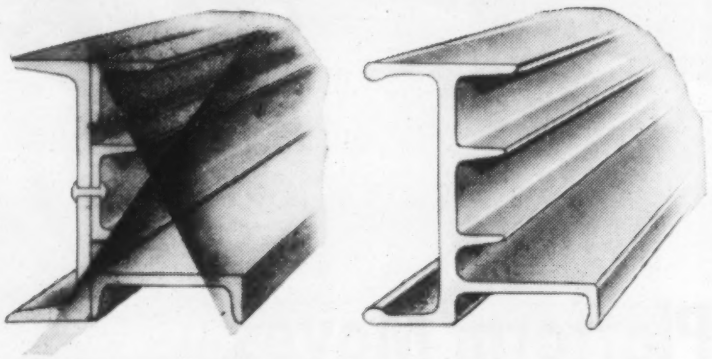
DIVISION OF THE WICKES CORPORATION, SAGINAW 3, MICHIGAN

GRAPHITAR® CARBON-GRAPHITE • GRAMIX® POWDERED METAL PARTS • MEXICAN® GRAPHITE PRODUCTS • USG® BRUSHES

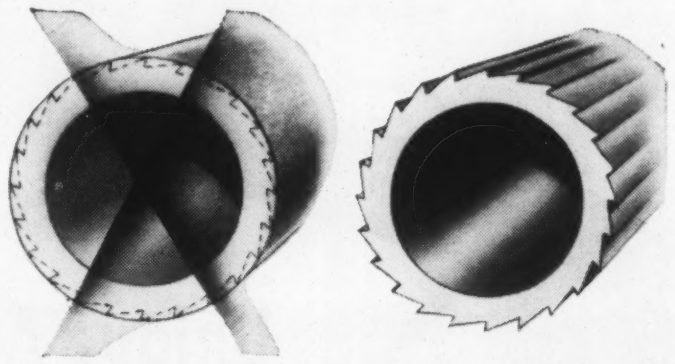
For more information, turn to Reader Service card, circle No. 561

Cost-Cutting Aluminum Extrusions . . .

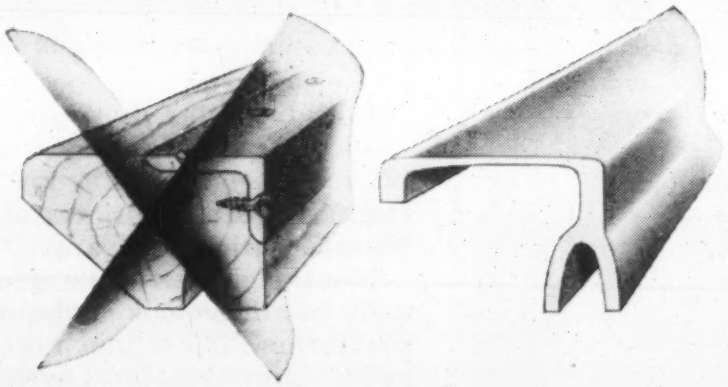
1. eliminate joining



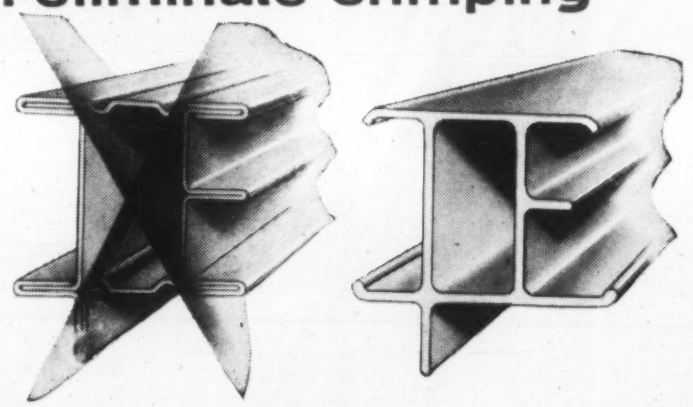
2. eliminate machining



3. eliminate reinforcing



4. eliminate crimping



HERE'S ONE WAY EXTRUSIONS SAVE AND IMPROVE . . .

NEW

Reynolds "ALL-AIR"* truck flooring

Here's a new Reynolds extruded aluminum product that really saves . . . both in production and in use. Made of simple, strong interlocking extruded aluminum panels, this new "All-Air" reefer flooring gives truck operators the light weight and heavy duty service they want. It would be impossible to produce this efficient, cost-cutting flooring any other way, in any other metal.

*TRADE MARK; U.S. PAT. PENDING

The Finest Products Made with Aluminum are made with REYNOLDS ALUMINUM

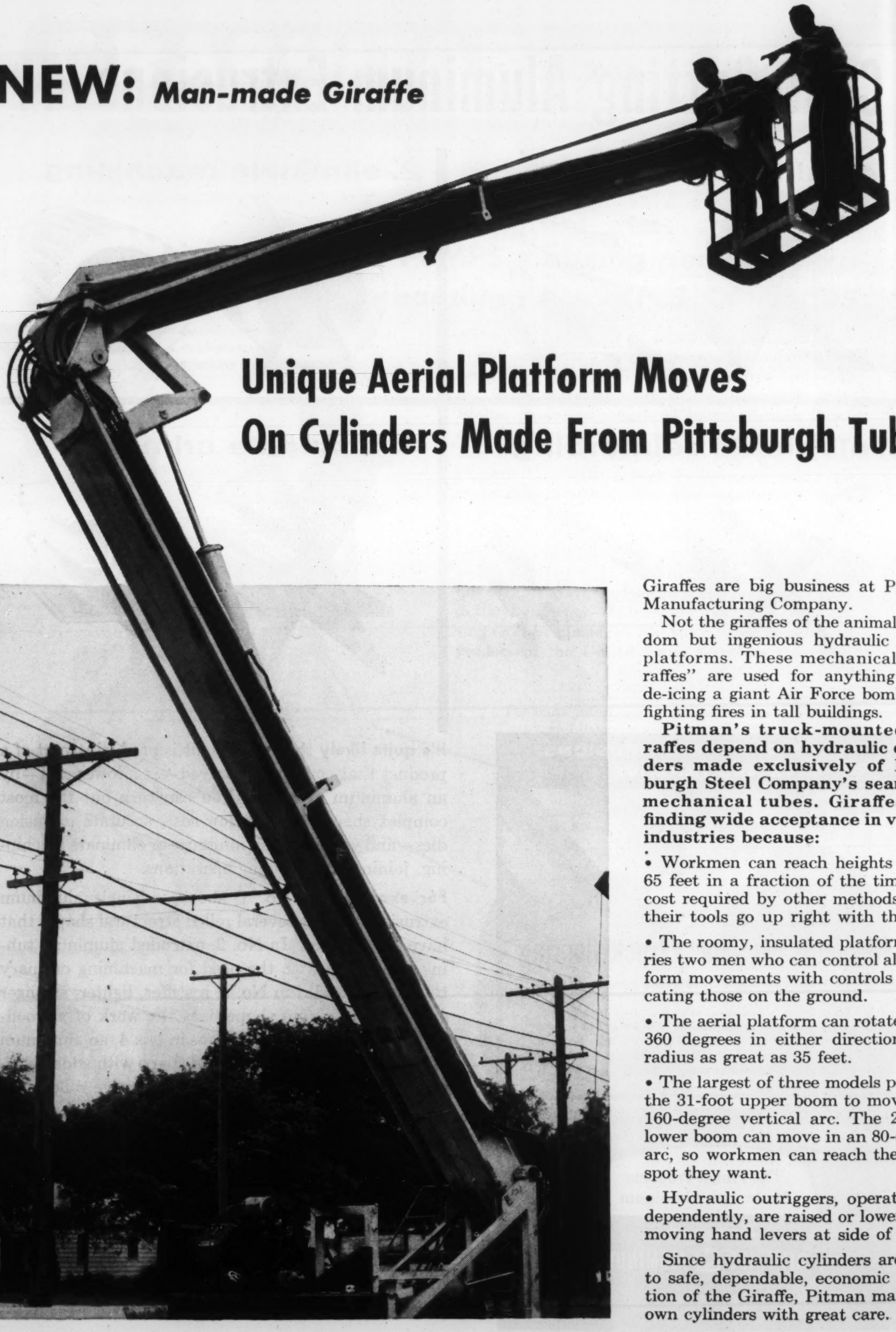
It's quite likely that your plant is producing part of a product that could be improved—at a lower cost—by an aluminum extrusion. You can turn out the most complex shapes through low-cost, accurate extrusion dies—and you can often minimize or eliminate machining, joining and finishing operations.

For example, in No. 1 above, a single aluminum extrusion replaces several rolled structural shapes that have to be joined. In No. 2, extruded aluminum tubing does away with the need for machining ordinary tubing or rod. Or, in No. 3, a stiffer, lighter, stronger extruded aluminum shape does the work of a wood-supported metal angle. And, as in No. 4, an aluminum extrusion provides the required shape with added stiffness and without investment in expensive roller dies.

Reynolds Design and Engineering Services will work with engineers and design consultants in improving and cutting the cost of your products with extrusions and other forms of aluminum. For their assistance or to obtain a complete aluminum literature and movie index, call the Reynolds office, listed under "Aluminum" in your classified phone book. Or write *Reynolds Metals Company, P. O. Box 1800-HM, Louisville 1, Kentucky.*

For more information, turn to Reader Service card, circle No. 523

NEW: *Man-made Giraffe*



Unique Aerial Platform Moves On Cylinders Made From Pittsburgh Tubes

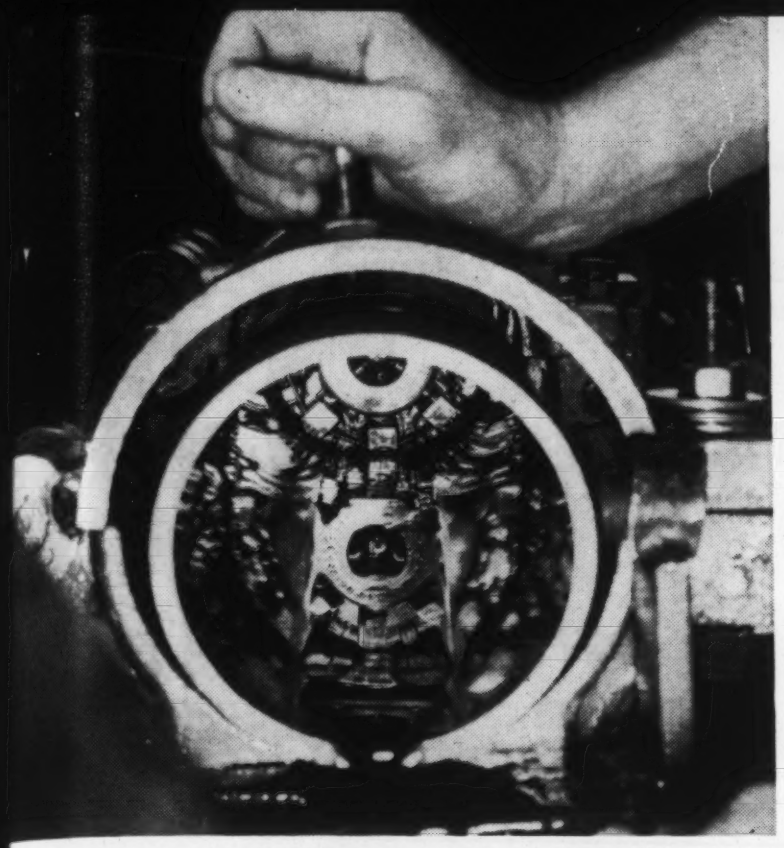
Giraffes are big business at Pitman Manufacturing Company.

Not the giraffes of the animal kingdom but ingenious hydraulic aerial platforms. These mechanical "Giraffes" are used for anything from de-icing a giant Air Force bomber to fighting fires in tall buildings.

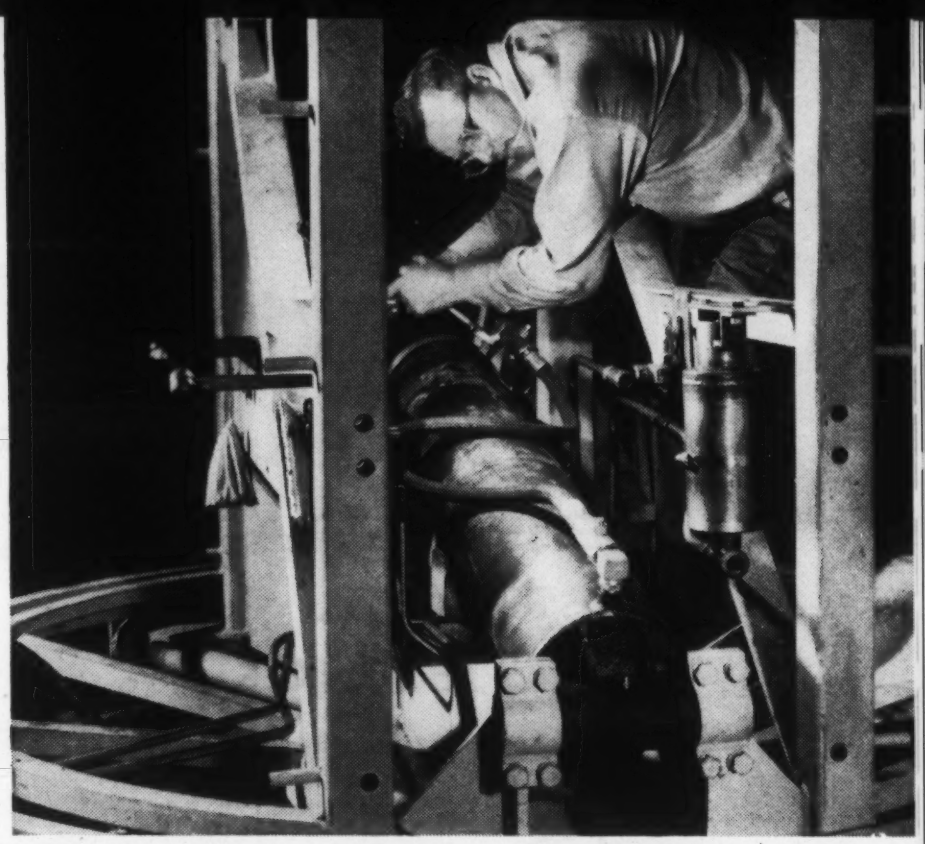
Pitman's truck-mounted Giraffes depend on hydraulic cylinders made exclusively of Pittsburgh Steel Company's seamless mechanical tubes. Giraffes are finding wide acceptance in varied industries because:

- Workmen can reach heights up to 65 feet in a fraction of the time and cost required by other methods. And their tools go up right with them.
- The roomy, insulated platform carries two men who can control all platform movements with controls duplicating those on the ground.
- The aerial platform can rotate a full 360 degrees in either direction in a radius as great as 35 feet.
- The largest of three models permits the 31-foot upper boom to move in a 160-degree vertical arc. The 23-foot lower boom can move in an 80-degree arc, so workmen can reach the exact spot they want.
- Hydraulic outriggers, operated independently, are raised or lowered by moving hand levers at side of truck.

Since hydraulic cylinders are vital to safe, dependable, economic operation of the Giraffe, Pitman makes its own cylinders with great care.



Horizontal honing of Pittsburgh Steel tubes is an exacting process. Inside the tube, you can see part of the hones. At the end of the tube, the hones are mirrored on polished steel.



Finished cylinder is installed on turntable of Pitman Giraffe. This cylinder supports and moves the lower boom. Completed Giraffe will be mounted on truck supplied by customer.

All Giraffe hydraulic cylinders are made from tubing produced by the Tube Mills of Pittsburgh Steel Company and sold by the Kansas City distributor, Metal Goods Corporation.

"We get high production from tubes because Pittsburgh tubes hold to close tolerances," declared Arthur Moore, vice president and general manager of Pitman Manufacturing. He added:

"We give Pittsburgh Steel tubes credit for cutting our scrap losses. But economy isn't all we're thinking of. Since we never forget that men's lives depend on our cylinders we build a safety factor of at least three into every cylinder. We've never had a burst cylinder or a cylinder wall failure with Pittsburgh tubes.

"Finally, Pittsburgh Steel gives us the kind of service we like."

Mr. Moore said engineers from Pittsburgh Steel helped analyze the company's tube problems, suggested some design changes and took Pitman's prints back to the mill to make tubing which exactly fills the bill.

"The service which Pittsburgh Steel instituted ended our tubing problems," said Mr. Moore. "Our cylinders have been very satisfactory ever since."

Whether you make hydraulic cylinders or use seamless mechanical tubing in another application needing uniformity, close tolerances and engineering help, you can profit by Pitman's experience.

Start today by getting in touch with trained help available through any Pittsburgh Steel Company District Office or from one of the Pittsburgh Steel distributors listed at right.

Fire-fighting is just one of many uses for the Pitman Giraffe. These firefighters can move their platform to any given spot quickly and easily without losing time when time counts most.

Pittsburgh Seamless Distributors

Baker Steel & Tube Company
Los Angeles, California

Chicago Tube & Iron Company
Chicago, Illinois

Cleveland Tool & Supply Co.
Cleveland, Ohio

Drummond McCall & Co., Ltd.
Montreal, Quebec, Canada

Edgcomb Steel Company
Philadelphia, Pennsylvania

Gilmore Steel & Supply Co.
San Francisco, California

Earle M. Jorgensen Co.

Perry Kilsby, Inc.
Los Angeles, California

Mapes & Sprowl Steel Co.
Union, New Jersey

Metal Goods Corporation
St. Louis, Missouri

Miller Steel Company, Inc.
Hillside, New Jersey

A. B. Murray Co., Inc.
Elizabeth, New Jersey

C. A. Russell, Inc.
Houston, Texas

Ryerson, Joseph T. & Son, Inc.
Chicago, Illinois

Solar Steel Corporation
Cleveland, Ohio

Steel Sales Corporation
Chicago, Illinois

Tubular Sales
Detroit, Michigan

Ward Steel Service Company
Dayton, Ohio

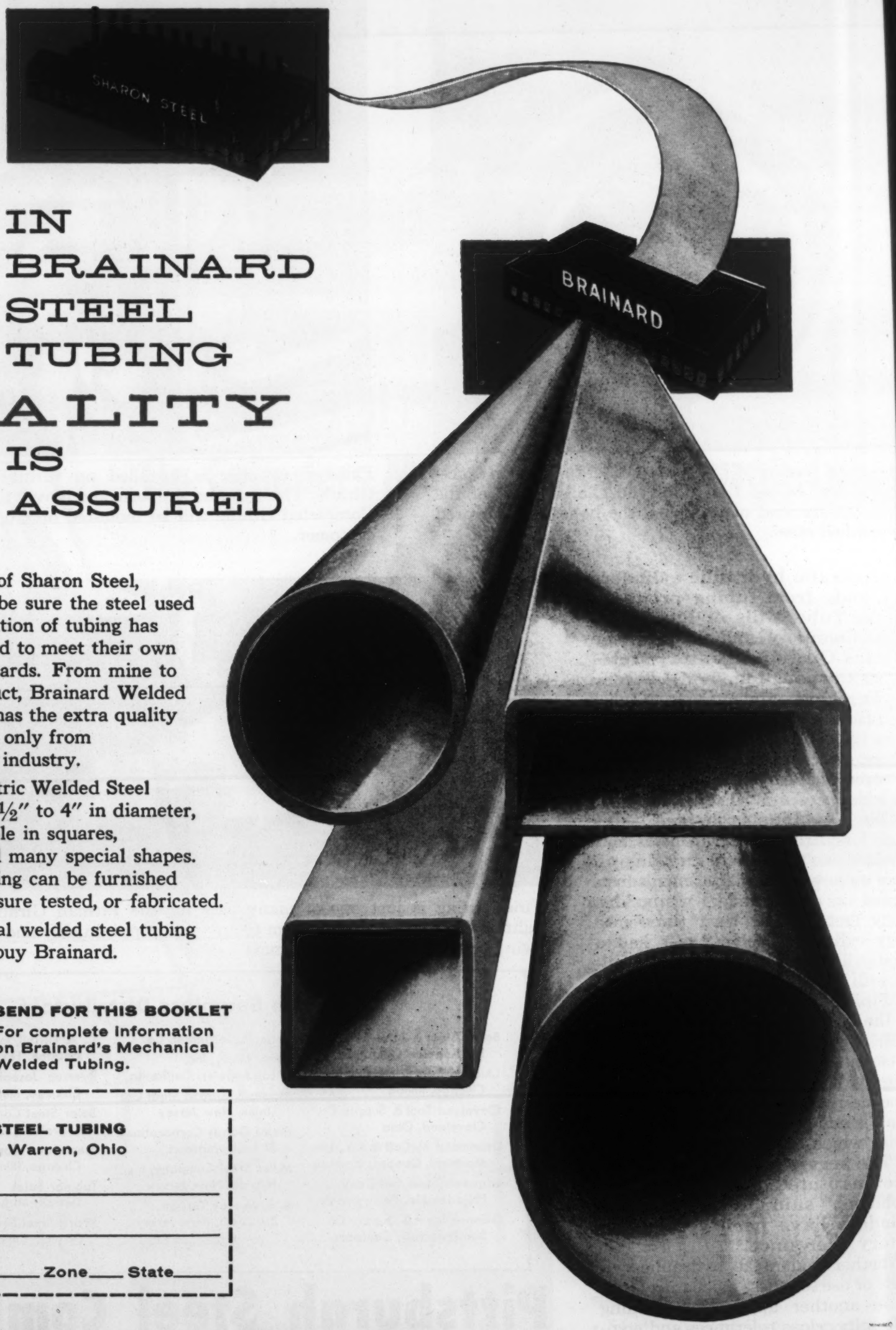
Pittsburgh Steel Company

Grant Building • Pittsburgh 30, Pa.

District Sales Offices

Atlanta, Chicago, Cleveland, Dallas, Dayton, Detroit, Houston, Los Angeles, New York, Philadelphia, Pittsburgh, Tulsa, Warren, Ohio

For more information, turn to Reader Service card, circle No. 444



IN BRAINARD STEEL TUBING QUALITY IS ASSURED

As a division of Sharon Steel, Brainard can be sure the steel used for the fabrication of tubing has been developed to meet their own exacting standards. From mine to finished product, Brainard Welded Steel Tubing has the extra quality that can come only from an integrated industry.

Brainard Electric Welded Steel Tubing, from ½" to 4" in diameter, is also available in squares, rectangles and many special shapes. Brainard Tubing can be furnished swedged, pressure tested, or fabricated.

For mechanical welded steel tubing of top value, buy Brainard.

SEND FOR THIS BOOKLET
For complete information on Brainard's Mechanical Welded Tubing.

BRAINARD STEEL TUBING
Griswold St., Warren, Ohio

Name _____

Address _____

City _____ Zone ____ State ____

Brainard Steel Tubing

SHARONSTEEL

Brainard Steel Division, Sharon Steel Corporation
Griswold Street, Warren, Ohio

For more information, turn to Reader Service card, circle No. 450

Now you can get standard sizes in C/R End Face Seals!

Chicago Rawhide now announces the availability of a complete new line of Standard End Face Seals to meet the widest possible range of sealing requirements. For sizes or conditions beyond the range of Standard End Face Seals, C/R engineers will continue to cooperate with you on special designs. Their experience in sealing applications is unmatched — your assurance of getting the correct seal for the job.

Write for your free copy of this new C/R Bulletin →

Bulletin EF-100 includes complete envelope space data on C/R Standard End Face Seals and mating rings to help you select the correct size for your equipment design:

- Size range table in two series — long and short — from ¾ to 4 inch shaft diameter.
- Size range table on mating rings.
- Typical seal installations for internal and external pressure.
- Special instructions on how to order.

OIL SEAL C/R DIVISION

CHICAGO RAWHIDE

CHICAGO RAWHIDE MANUFACTURING COMPANY

1227 ELSTON AVENUE • CHICAGO 22, ILLINOIS

Offices in 55 principal cities. See your telephone book.

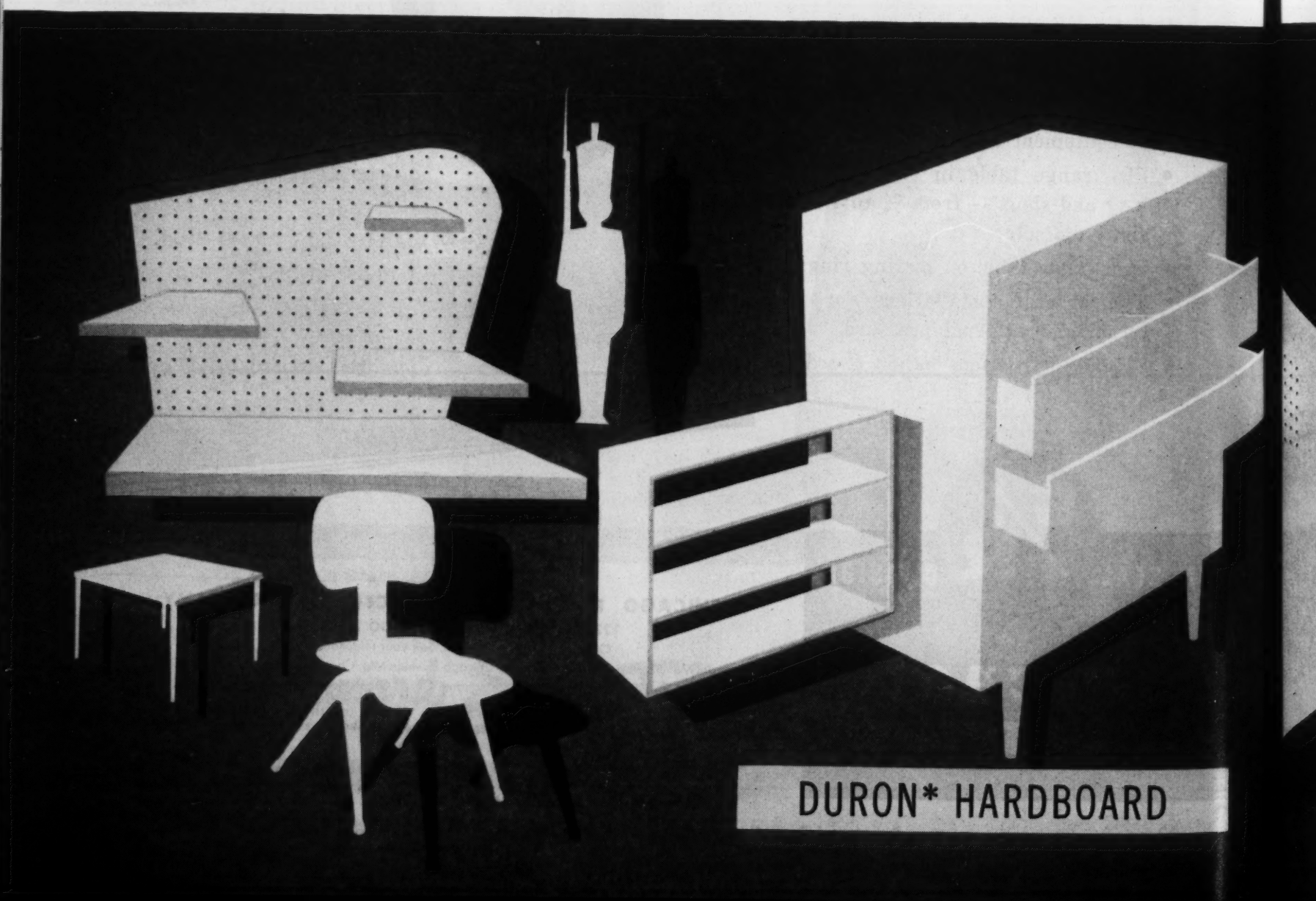
In Canada: Manufactured and Distributed by Chicago Rawhide Mfg. Co. of Canada, Ltd., Hamilton, Ontario.

Export Sales: Geon International Corp., Great Neck, New York

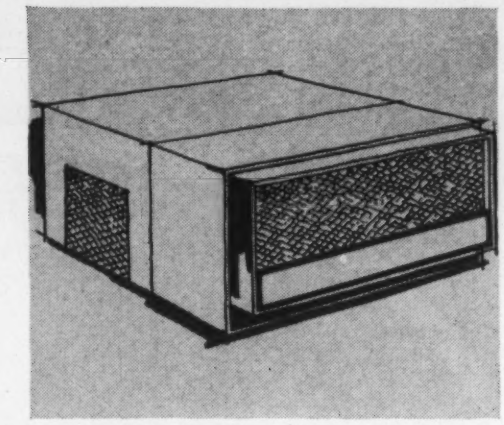
C/R PRODUCTS: C/R Shaft and End Face Seals • Sirvene (synthetic rubber) molded pliable parts • Sirvis-Conpor mechanical leather cups, packings, boots • C/R Non-Metallic Gears

For more information, turn to Reader Service card, circle No. 543

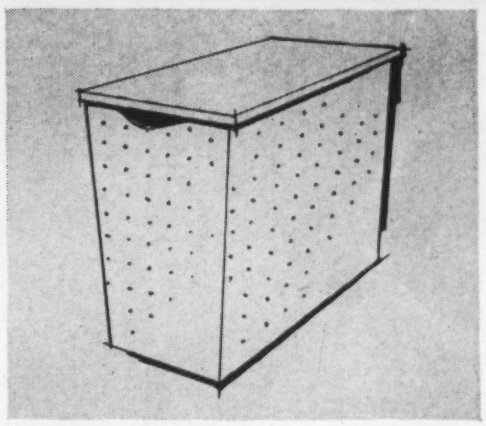
creative materials



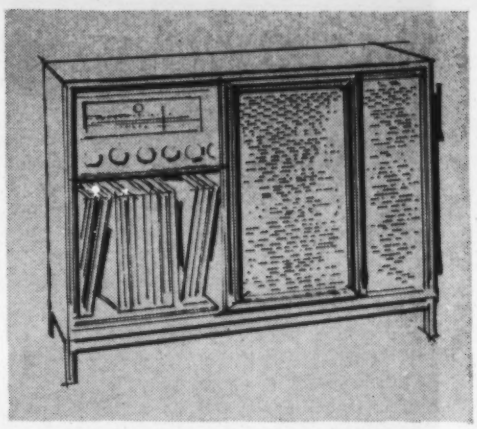
CREATIVE MATERIALS INSPIRE CREATIVE EXPRESSION IN PRODUCT DESIGN



USG EXPANDED METALS are cold-drawn from a solid sheet of aluminum or carbon steel; and in some meshes, stainless steel. They are strong, rigid and light in weight, and are readily formed, do not ravel in cutting, and weld easily.



DURON HARDBOARD is highly resistant to wear. Both sides have extra-smooth surfaces that take paint, high-gloss enamel and lacquer well without further finishing. DURON may be fastened with nails, rivets, screws or adhesives.



COUNTLESS USES have been found for these versatile materials. For Expanded Metals — utility racks, screens, shelves, safety guards, ornamental grilles. For DURON — cabinets, panels, stiffening boards, gaskets. Possibilities are unlimited!

to help your ideas take shape . . . by providing versatile combinations of beauty and strength

Your creative expression is limited only by the lack of suitable materials to translate ideas into a workable form. Here are two U.S.G. products that combine beauty, utility and fabrication flexibility to offer you greater freedom of design.

USG Expanded Metals — RONDO, FESTOON, WAVELENGTH, ARMORWEAVE and EXPAND-X* —provide strength without excessive weight. These artistically pleasing new meshes can carry the main design theme, or may serve only as ornamentation.

DURON Hardboard lends itself exceptionally well to complex patterns. The non-grain properties of this material permit rapid cutting, shaping and punching. Regardless of the type of finish DURON excels in paintability.

Whatever your product, you'll find these new U.S.G. creative materials invaluable inspiration *to help your ideas take shape.*

For more information, circle No. 541

USG UNITED STATES GYPSUM

UNITED STATES GYPSUM

pioneering in ideas for industry

*T.M.Reg.U.S.Pat.Off.

MAIL COUPON TODAY!

United States Gypsum, Dept. MD-3
300 West Adams Street, Chicago 6, Illinois

- ☐ Please send free literature about USG Expanded Metals.
- ☐ Please send free literature about USG DURON Hardboard.
- ☐ Please have a trained Sales Engineer contact me.

NAME_____

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now available from Trent–

Titanium Tubing

For processing lines carrying fluids of an extremely corrosive nature — look to *Contour Trentweld* titanium tubing for reliable service.

This titanium tubing is completely uniform throughout any cross-section. The weld zone is free from bulging weld bead because Trent's exclusive process — performed with the weld area at the bottom — forms the molten weld metal into the shape of the tubing.

And, with titanium, you get the unique advantages of a tubing that's strong as steel but 44% lighter . . . virtually immune to a broad spectrum of corrosive materials . . . entirely free from stress-corrosion cracking.

So, next time you need a strong, light, extremely corrosion-resisting tubing — try *Contour Trentweld* titanium tubing. And remember, it's made by Trent — tube mill specialists.

CONTOUR TRENTWELD

Stainless and High Alloy Welded Tubing

TRENT TUBE COMPANY, GENERAL SALES OFFICES, EAST TROY, WISCONSIN (Subsidiary of Crucible Steel Company of America)

For more information, turn to Reader Service card, circle No. 475

—its construction and finish help start the sale. That's why so many air-conditioner manufacturers turn to General American for plastic moldings.

Logical source for *you*, too. Only at General American does your product get the benefit of pioneering experience in plastics molding–highly specialized facilities unduplicated elsewhere in the industry—and the personal attention of a customer service man assigned to live with your job through every step of production.

No wonder America's leading manufacturers have found . . . *it pays to plan with General American.*

PLASTICS DIVISION GENERAL AMERICAN TRADE MARK

Plastics Division
GENERAL AMERICAN TRANSPORTATION CORPORATION
135 South LaSalle Street • Chicago 90, Illinois

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Celanese

OFFERS ALL

PACKAGING

The unique properties of Fortiflex-A—particularly its toughness and resistance to chemical attack at elevated temperatures — offer new opportunities in the packaging of food, drugs, cosmetics and chemicals. Applications for Fortiflex-A include: thin wall bottles and vessels . . . light weight, disposable containers vacuum formed from sheet stock . . . sterilizable films and coatings.

Injection Molded Bottles and Containers

Fortiflex-A molds easily in existing polyethylene molds. However, its great rigidity and toughness make possible impressive economies in wall thickness when molds are specially built. Savings in material weight over conventional polyethylene average as high as 40%. The exceptional thermal resistance of Fortiflex-A permits the packaging of hot liquids and semi-solids at temperatures up to 225° F., as well as surgical equipment that requires post-packing sterilization. Its chemical and permeation resistance recommend it as a replacement for expensive materials in the packaging of highly corrosive chemicals.

Blown Bottles and Containers

Lightness with strength and rigidity are obtainable in blow moldings of Fortiflex-A. This molding technique offers valuable economies in material weight, a faster rate of production and real savings in shipping costs of packaged merchandise. When protection against light is required, dense pigment can be incorporated so as to give complete opacity. Blow molded bottles of Fortiflex-A can be produced at only ⅛ the weight of glass and ¼ the weight of metal.

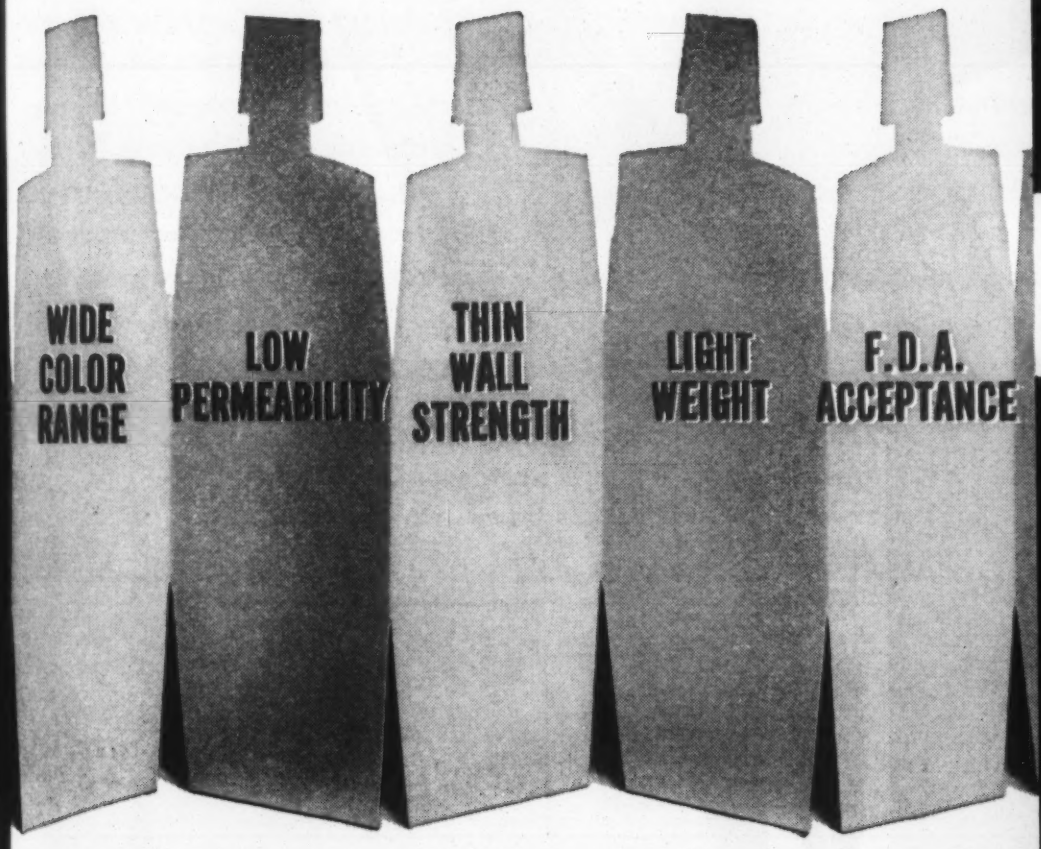
Supported and Unsupported Films

As a potential material for supported and unsupported films, the packaging advantages of Celanese Fortiflex-A open up a new range of opportunities in food, medical and industrial packaging. Films of Celanese Fortiflex-A will make possible sterilization after packaging. They exhibit great toughness and durability, virtually zero vapor transmission, and good transparency. The characteristic rigidity of Celanese Fortiflex-A will produce a film easily handled on standard automatic packaging machinery.

FORTIFLEX-A

A POLYOLEFIN PLASTIC

THESE ADVANTAGES



Vacuum Forming

Extruded sheeting of Celanese Fortiflex-A exhibits excellent vacuum forming characteristics. Deep drawing qualities and minimum post-mold shrinkage give advantages in this application. The great toughness and durability of extruded sheeting of Celanese Fortiflex-A are factors that will contribute to more efficient, more economical packaging. Extruded sheeting of Celanese Fortiflex-A is now available from suppliers. The Celanese Sales Development Department will be glad to supply names and addresses.

For complete information about Celanese Fortiflex-A—production-run quantities, test quantities, prices—write Sales Development Department, Celanese Corporation of America, Plastics Division, Dept. 102-L, 290 Ferry Street, Newark 5, N. J.

Celanese® Fortiflex®

Celanese PLASTICS and RESINS

Celanese Corporation of America, Plastics Division, Newark 5, N. J.

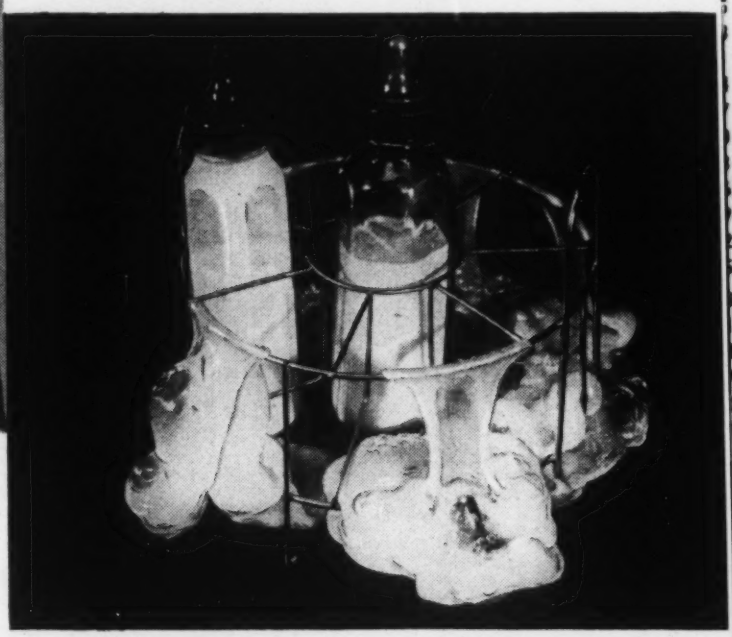
Canadian Affiliate: Canadian Chemical Co., Limited, Montreal, Toronto, Vancouver

Export Sales: Amcel Co., Inc., and Pan Amcel Co., Inc., 180 Madison Avenue, N. Y. 16, N. Y.

For more information, turn to Reader Service card, circle No. 533

2 REASONS WHY FORTIFLEX-A BELONGS IN YOUR PACKAGING PROGRAM

STRENGTH AND RIGIDITY IN THIN WALLS! Camera time-exposure dramatizes toughness and rigidity of Fortiflex-A. Liquid filled, blown bottle is dropped from approximately shoulder height onto hard surface. Close-up, taken after test, shows bottle to be undamaged.



HEAT RESISTANCE! Laboratory test displays the superior heat resistance of Celanese Fortiflex-A. Bottles molded of Celanese Fortiflex-A, glass and ordinary polyethylene were sterilized for 15 minutes at 15psi, 250°F. Only the glass bottle and Fortiflex-A bottle withstood the sterilization temperature. The ordinary polyethylene bottles were reduced to an amorphous state.

Sales Development Department, Celanese Corporation of America, Dept. 102-L, Plastics Division, 290 Ferry Street, Newark 5, N. J.

☐ I am interested in more information about Fortiflex-A for possible application as_____(enter number).

☐ Have a representative call on me.

Name_____

Title_____

Company_____

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Now—a major advance in

Arwood now bases its guarantees on specimens cut from the castings themselves.

aluminum investment castings!

Arwood now guarantees better-than-Aircraft-Quality properties in the casting itself

Arwood's Research Staff has perfected a new technique of investment casting aluminum . . . a technique that makes it possible to guarantee mechanical properties far higher than Aircraft Quality and guarantee them in the casting itself. The new Arwood "Suparcast" process gives you 37% greater tensile strength . . . 52% greater yield strength . . . a three-fold improvement in elongation . . . in all areas of the casting. In stressed areas, these minimums can be raised even higher!

And here's the real news: *These guarantees are based on specimens machined from actual castings.*

It's easy to understand how the new "Suparcast" process can help you shuck off the historical limitations of aluminum investment castings. Now at last you know exactly what properties you are getting in your castings. Now at last you can use aluminum investment castings for structural applications, even where shock and impact are involved.

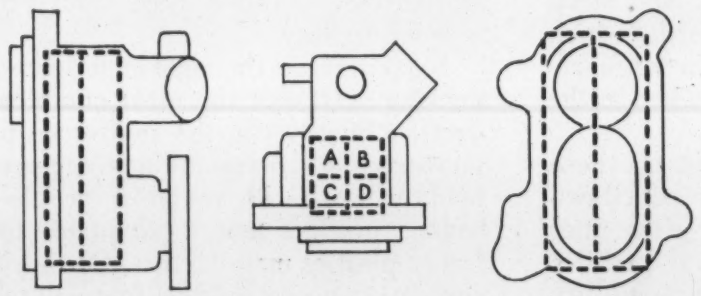
Another very practical consideration: If you are now using 356-T6 alloy investments, you can switch to castings made by Arwood's "Suparcast" process *without the need to change specifications.*

If you'd like to learn more about Arwood's new process, write, wire or 'phone for complete details.

COMPARISON OF MINIMUM MECHANICAL PROPERTIES OF 356—T6 ALUMINUM ALLOY
Suparcast Guaranteed Minimums vs. Government Aircraft Quality Minimums
(Test bars cut from castings weighing less than five pounds and with maximum sections less than 1" thick.)

	Ultimate Tensile Strength		Yield Strength		Elongation	
	psi	% increase	psi	% increase	%	% increase
AMS 4260	24,750	—	16,500	—	0.7	—
Arwood Suparcast (all areas)	34,000	37.4	25,000	51.5	3	300
Arwood Suparcast (critical areas)	38,000	53.5	27,000	63.6	5	600

HERE ARE ACTUAL MECHANICAL PROPERTIES IN VARIOUS AREAS OF THE CASTING SHOWN AT THE LEFT:



Test bar location	Ultimate (psi)	Yield (psi)	Elongation %
A	38,800	28,400	5
	37,600	28,600	4½
B	38,800	28,600	4
	37,500	27,000	5
C	41,300	29,200	9
	39,800	27,400	6
D	40,000	26,500	5
	37,400	27,600	4

arwood

ARWOOD PRECISION CASTING CORP.
317 West 44th Street, New York 36, New York

A complete service from design through tooling, production and finish machining. Sixty-two engineering consultants from coast to coast.

PLANTS IN BROOKLYN, N.Y.; GROTON, CONN.; TILTON, N. H.; LOS ANGELES & N. HOLLYWOOD, CALIF.

For more information, turn to Reader Service card, circle No. 448

From the needle-nose radome of a supersonic fighter
comes a new steel-strong material for industry

Have you seen these rugged, colorful cabinets for the new Motorola portable record player?

They'll keep their good looks—
because they're made of resin-bonded glass fiber

It was a formidable list of requirements that Motorola gave to 3M for the cabinet of its new portable record player.

The cabinet was designed as a contoured and sculptured form, for both function and beauty. It had to be extremely lightweight —yet so strong and so tough that it could endure years of use and abuse without denting or scuffing. And it had to be made in a variety of permanent colors.

The intricate form ruled out wood. It could have been stamped in metal, but the lightweight metals dented too easily and the stronger metals were too heavy. And metal would have called for a paint finish (which would eventually mar) or some sort of fabric covering (which would have added to the cost).

Resin-bonded glass fiber met all these exacting requirements—and even added two important bonus features: the glass fiber cabinet has much better acoustical qualities than metal, and it eliminates the possibility of electrical shock from the cabinet. There are no seams to open, no joints to split. The modern decorator colors are permanently fused into the glass-and-resin shell. The lustrous surface is dent- and scuff-proof. It is not affected by heat, humidity, sun, or rain. Grease, oil, and ink wipe off clean.

3M's high-strength structural plastics are basically the same type of material used in airborne radomes, the thin shells that house radar equipment. They are ideal for a wide variety of consumer and industrial products. They always add quality and sales appeal... often reduce the unit cost. They can be formed to almost any contour, in almost any size—at production-line speed. Motorola's colorful cabinets are forerunners of other stylish resin-bonded glass fiber products now on the way.

Today 3M has the most experienced engineering staff and the most complete production facilities in the reinforced-plastics industry. 3M's designers and engineers are ready to work with your own people if you have a product that is adaptable to reinforced-plastics manufacture. Or they'll help you design a new product that will take full advantage of the unique qualities of structural plastics. For more information, write on your letterhead to 3M Company, Box 91, Gardena, California.

Minnesota Mining & Manufacturing Company
Reinforced Plastics Group
Zenith Plastics Company Subsidiary, 1600 West 135th Street, Gardena, California
World's most experienced manufacturer of resin-bonded glass fiber products

FORM OF THE FUTURE: RESIN-BONDED GLASS FIBER

For more information, turn to Reader Service card, circle No. 519

Goodrich-Gulf Chemicals, Inc.

Ameripol... HOT POLYMERS

Types	*Physical Properties**	*Selection Guide*
1000	Tensile . . . . . 3030 psi. Elongation . . . . . 600 % Modulus @ 300% Elongation . 980 psi. Mooney Viscosity— ML212°F. @ 4 minutes . . Raw Polymer . . . . . 48 Compounded Stock . . . 55	General purpose rubber for products where color unimportant. Used for tires, molded and extruded products.
1001	Tensile . . . . . 3030 psi. Elongation . . . . . 600 % Modulus @ 300% Elongation . 1010 psi. Mooney Viscosity— ML212°F. @ 4 minutes Raw Polymer . . . . . 47 Compounded Stock . . . 55	Similar to 1000, but less staining and discoloring. For tires, shoe soles and heels, molded and extruded products.
1002	Tensile . . . . . 3000 psi. Elongation . . . . . 650 % Modulus @ 300% Elongation . 950 psi. Mooney Viscosity— ML212°F. @ 4 minutes Raw Polymer . . . . . 53 Compounded Stock . . . 55	Rosin acid soap provides more processing tack and lower modulus than 1000 and 1001. For tires, molded and extruded products.
1006	Tensile . . . . . 2850 psi. Elongation . . . . . 590 % Modulus @ 300% Elongation . 1010 psi. Mooney Viscosity— ML212°F. @ 4 minutes Raw Polymer . . . . . 50 Compounded Stock . . . 58	An improved, lighter colored rubber, relatively non-discoloring and non-staining. For white and pastel colored products—tile, toys, side walls, etc.
1007	Tensile . . . . . 2760 psi. Elongation . . . . . 620 % Modulus @ 300% Elongation . 890 psi. Mooney Viscosity— ML212° @ 4 minutes Raw Polymer . . . . . 48 Compounded Stock . . . 54	Relatively low water absorption, improved electrical properties. For insulation and electrical products, gaskets, etc.
1009	Tensile . . . . . 1850 psi. Elongation . . . . . 360 % Modulus @ 300% Elongation . 770 psi. Mooney Viscosity— ML212°F. @ 4 minutes Compounded Stock . . . 126	A cross-linked polymer used with other polymers to reduce shrinkage and die swell in calendering and extrusion. For footwear, insulation, calendered goods.

***Typical average, production values. Cure 50′ at 292°F.**

Hot polymer man-made rubber easily processed... furnished in bale or crumb form

Ameripol is the preferred butadiene-styrene rubber . . . superior or equal to natural rubber in aging, resistance to wear, weathering, water, oil, permeability to gases.

The hot polymer grades are most easily processed. Furnished in compressed bale form for molded and extruded products; in crumb form for solubility in adhesives, mastics, cements. Because of low molecular structure, Ameripol hot polymers go into solution easily and quickly.

Write for free copy
of 24-page booklet "Ameripol—the preferred rubber". Complete technical data helps you select and specify.

Ameripol RUBBER

Cold Non-Oil Polymers
•
Cold Oil-Extended Polymers
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Hot Non-Oil Polymers

Goodrich-Gulf Chemicals, Inc.
3121 Euclid Avenue • Cleveland 15, Ohio

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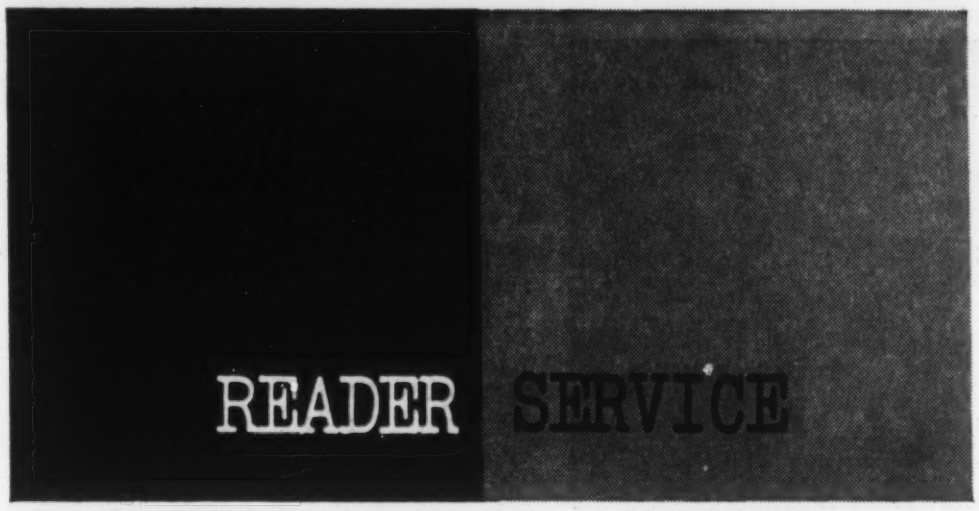

helps you get up-to-date technical bulletins and details on advertised products

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from the selected list of new bulletins reviewed on the pages immediately following this insert. You will also find, under subject headings, a cumulative list of current technical literature suitable for your reference files. To obtain bulletins, circle the appropriate numbers on one of the return postal cards and drop it in the mail.

2. INFORMATION ON ADVERTISED PRODUCTS . . .

which will also be forwarded to you if you will circle on the free return postal card the code numbers that appear with the advertisements in which you are interested.

Want Manuals?

Reader Service will fill orders for both Materials & Methods and MATERIALS IN DESIGN ENGINEERING MANUALS. *All Manuals are reprinted and are available for a nominal handling charge. For an order blank and a list of Manuals still available, see page 236.*

December 195

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MANUFACTURERS' LITERATURE

New Literature

Small Metal Stampings. Advance Stamping Co., 12 pp, illus. Illustrates such small metal stampings as oil cups, terminals, drawn shelves and special parts. Shows production facilities. (1)

Leaded Steel Rings. Alco Products, Inc., 8 pp, illus., No. SF-2. Outlines advantages and uses of forged and rolled rings made of leaded steel. Gives physical properties and sizes of leaded steel rings. (2)

Plastics Compounds. Barrett Div., Allied Chemical & Dye Corp., 4 pp, illus., No. P-95. Briefly describes heat and chemical resistance, quality, strength and electrical properties of urea, melamine, alkyd and nylon molding compounds. Shows typical applications. (3)

Investment Castings. Alloy Precision Castings Co., 2 pp, illus. Gives chemical composition and physical properties of ferrous and nonferrous alloys commonly used for investment castings. Gives design information. (4)

Copper Products. American Brass Co., 60 pp. Lists sizes, dimensions and availability of copper and brass strip, sheet, wire, rod and tube. Also, information on brass, bronze, steel and aluminum flexible metal hose. (5)

Lithium. American Lithium Institute, Inc., 4 pp, Vol. 1, No. 1. Reviews new developments in the field of lithium and summarizes current articles on lithium appearing in trade and business publications. (6)

Stainless Steel Strip. American Silver Co., 2 pp. Gives mechanical properties, heat resistance characteristics and chemical composition of 200 and 300 series stainless steel strip. Shows the effect of heat treating these strips in terms of changes in yield and tensile strengths. (7)

Stainless Steels. Armco Steel Corp., 28 pp, illus., No. PO-4757. Gives design and fabrication advantages, available forms and sizes, properties, machining data and uses of two precipitation hardening stainless steels. Examples of improved product design are detailed and illustrated. (8)

Steel Tubing. Tubular Products Div., Babcock & Wilcox Co., 8 pp, illus., No. TD-419. Gives mechanical properties, strength, ductility and hardness of welded, normalized and drawn carbon steel tubing. Outlines advantages of tubing and gives dimensional tolerances. (9)

Polyvinyl Alcohol. Chemical Div., Borden Co., 23 pp, No. M 13-T. Outlines properties and uses of a series of polyvinyl alcohols used in paper coatings and saturants, adhesives and sizings. (10)

Thermoplastic Resin. Marbon Chemical Div., Borg-Warner Corp., 4 pp, illus., Vol. 1, No. 2. Outlines advantages of using a high impact thermoplastic resin in clock cases, knife handles and postformed trays. Gives tensile strength, elongation and stress-strain properties of the resin at various temperatures. (11)

Vinyl-Metal Laminates. Industrial Div., Clad Rex Corp., 8 pp, illus. Gives results of physical, corrosion resistance, abrasion and weathering tests performed on the company's vinyl-metal laminate. Outlines features, uses and construction of the product. (12)

Rubber Compounds. Colonial Rubber Co., 16 pp, illus. Gives properties and advantages of the company's line of synthetic and "Silicol" silicone rubber compounds. Shows typical rubber parts manufactured by the company, and describes company's facilities. (13)

Copper Products. Copper & Brass Research Assn., 16 pp, illus., No. 182.

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Information on forms and tempers of copper and its alloys. Shows several ways in which copper is used in products ranging from door knobs to a discharge pipe for a Navy transport. (14)

Metal Powder Parts. Dixon Sintaloy, Inc., 12 pp, illus. Gives chemical composition, density, elongation, tensile strength and other features of brass, bronze, copper, nickel silver, steel and iron powder parts. Shows a number of metal powder parts for automotive, appliance, electronic, machine tool and instrumentation uses. (15)

Silicone Rubber. Dow Corning Corp., 4 pp, illus., No. 9-105. Gives dielectric properties of silicone rubber at temperatures from 75 to 500 F. Shows use of the material as an insulation on transformer and motor coils, wire and cable, strip heaters and electronic assemblies. Describes use of silicone as a potting and encapsulating material. (16)

Neoprene Products. Elastomer Chemicals Dept., E. I. du Pont de Nemours & Co., 12 pp, illus., No. 77. Current *Elastomers Notebook* discusses use of neoprene rubber in gaskets, seals and interliners for window walls and ball bearing units. (17)

Corrosion Resistant Coating. Electrofilm, Inc. No. 2055. Outlines advantages and uses of a corrosion resistant coating that is said to withstand 1300 hr of salt spray. (18)

Bi-Metallic Parts. Al Fin Div., Fairchild Engine & Airplane Corp., 4 pp, illus. Information on the use of aluminum and magnesium alloys bonded to steel and cast iron for brake drums, gears, impeller wheels, piston rings and magnetic tape reels. (19)

Wood Sheets. Fibron Products, Inc., 4 pp. Briefly outlines properties, advantages and uses of a wood sheet material called "Stamina" wood. The wood product consists of several resin-impregnated sheets of wood veneers fused into one material. (20)

Natural Mica. Ford Radio & Mica Corp., 2 pp, illus., No. 2661. Discusses quality and grading of natural mica sheets. Gives information on natural mica characteristics, sheet thickness and dimensional tolerances. (21)

Stainless Steel. Peter A. Frasse & Co., Inc., 2 pp, No. 2. Gives chemical composition of stainless steel bar, forgings, plate, sheet, strip, pipe and tubing to meet Air Force, Navy Aeronautical and Federal specifications. Lists nearest corresponding SAE, AISI and AMS numbers. (22)

Electrical Insulation. Furane Plastics, Inc., 3 pp. Gives physical properties, volume resistivities, dielectric constants, dissipation factors and heat distortion temperatures of a series of epoxy resins. Also typical applications. (23)

Polycarbonate Resin. Chemical Development Dept., General Electric Co., 4 pp. Information on uses, chemical, physical and electrical properties, availability and fabrication of a polycarbonate resin molding compound. (24)

Polyurethane Rubber. Chemical Div., General Tire & Rubber Co., 20 pp, illus. Outlines physical, thermal, adhesive, chemical and low temperature properties of a polyurethane rubber. Discusses the effect of carbon black, plasticizer and accelerator on properties of the rubber. (25)

Plastics Moldings. Glass Laboratories Inc., 4 pp, illus. Outlines advantages, features and dimensional tolerances of brass, chromium, copper and gold finished plastics moldings. Discusses their use in automobiles, lighting fixtures, boats and wheel goods. (26)

Barrel Finishing. Frederick Gumm Chemical Co. Inc., 20 pp, illus. Gives general information on ball tumbling. Discusses tumbling operations with both metallic and nonmetallic mediums and describes ball burnishing of plated and unplated steel parts. (27)

Stainless Steel Screws. Aero Div., H. M. Harper Co., 4 pp. Lists fillister, countersunk, round and truss head screws made of type 430 stainless steel that meet military (AN) specifications. (28)

Titanium Bolts. Hi-Shear Rivet Tool Co., 4 pp, illus. Outlines design features and tensile and shear strength properties of titanium and stainless steel bolts. Shows how bolts may be installed and outlines a number of their uses in industry. (29)

Chromium Wire. Hoskins Mfg. Co., 20 pp, illus., No. M-57A. Metallurgical data and design information on an 80-20 nickel-chromium resistance wire and ribbon used as heating elements in furnaces, ranges and other high temperature electrical heating applications. Includes prices and specifications for chromium wire, ribbon and strip. (30)

Nickel Alloy Products. International Nickel Co., Inc., 10 pp, illus., Vol. 10, No. 8. Discusses use of nickel and nickel alloys in shell molded crankshafts, in steel injection press frames, in stainless steel tank linings and in boiler tubing. (31)

Fluorocarbon Laminate. International Resistance Co., 4 pp, illus., No. LT-2. Comprehensive data on size, thickness, properties, current carrying capacity, finish and handling of a fluorocarbon-base copper foil laminate for printed circuit applications. (32)

Steel Bars. LaSalle Steel Co., 12 pp, illus. Discusses machining, heat treating, cleaning and grinding of copper-containing steel bars. Contains a complete bibliography. (33)

Magnesium Castings. Magline Inc., 8 pp, illus. Discusses design, research, engineering and production of magnesium sand castings. Shows company production, testing, inspection and storage facilities. (34)

Titanium Alloys. Mallory-Sharon Metals Corp., 24 pp, illus. Discusses metallurgy, corrosion resistance properties, machining, welding and testing of titanium alloys. Gives physical and mechanical properties and chemical composition of various titanium alloys. (35)

Alloy Castings. Meehanite Metal Corp., 4 pp, illus., No. 5. Outlines properties and advantages of Meehanite metal castings. Shows uses of 26 different types of Meehanite metal in tractor transmission housings, milk homogenizers, crankshafts and goosenecks. (36)

Metal-Wood Laminate. Met-L-Wood Corp., 16 pp, illus., No. 522. Lists woods and metals used in making Met-L-Wood laminates and compares stiffness and weight of the laminate with properties of oak, steel and aluminum. Shows how to fabricate and install the laminate and gives typical applications. (37)

Moldproof Paper. Mosinee Paper Mills Co., 2 pp, No. 101. Outlines advantages, properties and uses of a mold resistant paper. Briefly describes laboratory and field evaluation tests performed on the paper. (38)

Fiberglass Tubing. Pacific Laminates, Inc., 2 pp, illus. Gives physical and electrical properties, weight, dimensional tolerances and prices of three types of tubular fiberglass parts. Shows use of the tubing as fishing rods, antennas and handles. (39)

Coatings for Aluminum. Parker Rust Proof Co., 4 pp, illus. May '57 issue of *Parkerizer* discusses the advantages and corrosion resistance properties of two color finishes for aluminum. Shows treated and untreated aluminum heat exchangers after 1150 hr in salt spray. (40)

Molding Polyethylene. Plastics Sales Div., Phillips Chemical Co., 8 pp, illus. Discusses injection molding of rigid polyethylene with reference to feeding methods, cylinder temperatures, injection pressures, speed and mold temperatures. Also discusses properties and uses of rigid polyethylene. (41)

Titanium Alloys. Republic Steel Corp., illus., No. ADV-903. Explains and illustrates titanium production and processing at Republic Steel. Gives mechanical properties and typical uses of various titanium alloys. (42)

Heat Resisting Alloys. Rolled Alloys, Inc., 4 pp, illus. Information on sizes, dimensional tolerances and availability of hot and cold rolled heat resisting alloys. Shows company facilities. (43)

Resins for Rubber. Resins Div., Schenectady Varnish Co., Inc., 30 pp, illus. Gives properties of a line of liquid and powdered phenolic and resorcinal resins used in compounded rubber stocks for mechanical goods and adhesives. (44)

PVC Sheets. Plastics Div., Seiberling Rubber Co., 4 pp. Briefly outlines physical, chemical, electrical and thermal properties of an unplasticized polyvinyl chloride sheet material. Information on how to fabricate the material. (45)

Die Forged Parts. Smith-Armstrong Forge, Inc., illus. Illustrates and describes facilities for producing flat-die forged parts made of high speed, tool, alloy and stainless steels. Shows typical uses. (46)

Strippable Coatings. Spraylat Corp., 9 pp. Outlines type, color, uses, nonvolatile content, heat resistance, film thickness, spray application, drying

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time and coverage of a line of strippable protective coatings. (48)

Electrical Insulation. Electro Technical Products Div., Sun Chemical Corp., 8 pp, illus. Covers applications, base materials, temperature class and available finishes for over 30 different types of electrical insulation. Includes tensile and dielectric strength and size of insulation. (49)

Steel Shapes. Sun Steel Co., 24 pp, illus. Information on cold and hot rolled sheets, coils, strips, wires, angles, bars, structural shapes and bands. Includes properties and applications of embossed and vinyl coated metals. (50)

Metal Powder Parts. Superior Carbon Products, Inc., 4 pp, illus., No. M-2057. Gives hardness, tensile strength, density, elongation and porosity of tin, copper, brass, iron, steel and iron-copper metal powder parts. Also gives information on silver-graphite and silver metal powder parts. (51)

Gold Coatings. Technic Inc., 4 pp. Outlines use of a hard bright gold coating on waveguides, resistors, switches, alarms, safety devices and electrical contacts. Gives operating data on bath temperature and current density. (52)

Metal Finishing. Turco Products, Inc., 16 pp, illus. Describes and illustrates cleaning, phosphating, conversion coating, protective coating, paint and carbon removing, rust removing, descaling and electroplating of ferrous and nonferrous metals. Conversion factors, surface area measurements and bath compositions are given in tabular form. (53)

Phenolic Compound. Bakelite Co., Div. Union Carbide Corp., 8 pp, illus., No. 32. Gives mechanical, electrical and physical properties of a fast curing, black phenolic molding compound. Shows results of laboratory and field evaluation tests on curing. (54)

Thin Teflon Parts. Sparta Mfg. Co., Div. U.S. Ceramic Tile Co., 4 pp, illus. Describes a patented process of custom molding Teflon parts in thin sections and shapes. Outlines properties and characteristics of thin Teflon parts. (55)

Hard Facing Alloys. Wall-Colmonoy Corp., 12 pp, illus., No. 79. Gives composition, hardness, specific gravity, melting point, uses and abrasion, corrosion and impact resistance of nickel-cobalt and iron-base hard facing alloys. Lists uses of the alloys in the railroad, mining, iron and steel, lumber, automotive and aircraft industries. (56)

Rubber Products. Williams-Bowman Rubber Co., 12 pp, illus. Information on natural, synthetic and silicone rubber rings, gaskets, washers, tubing, cords, sheets and bar bumpers. Information also on rubber bonded-to-metal parts for vibration and shock resisting applications. (57)

Other Available Literature

Irons & Steels • Parts • Forms

Steel Bearings. Abbott Ball Co., 8 pp, illus. Discusses applications of carbon steel bearing balls and gives data on deep hardened and tempered steel bearing balls. (63)

Colored Stitching Wire. Acme Steel Co., 1 p. Selection guide for colored stitching wire. Colorstitch has a tough vinyl paint finish that resists chipping and peeling. (64)

Pearlitic Malleable Iron. Albion Malleable Iron Co., 23 pp, illus. Information on metallurgical characteristics of pearlitic malleable iron. (65)

Spun Steel Tubing. Special Products Div., American Cast Iron Pipe Co., 64 pp, illus. Shows fabrication of spun tubing. Tables, charts and graphs give dimensional data, physical properties and applications. (66)

Circular Steel Parts. Cleveland Welding Div., American Machine & Foundry Co., 26 pp, illus. Describes the Cleve-Weld Process and shows specialized production facilities for circular steel parts. (67)

Stainless Steel Fasteners. American Screw Co., 7 pp. Gives physical properties and applications of stainless steel fasteners. (68)

Nickel Lined Pipe. Bart Mfg. Corp., 8 pp, illus. Gives fabrication techniques and information on applications of nickel lined pipe and fittings in the paper, chemical, pharmaceutical and food industries. (69)

Precision Casting Process. Morris Bean & Co., 4 pp, illus. Describes Antioch process for producing castings that meet waveguide specifications in all bands. (70)

Bar Steels. Bliss & Laughlin, Inc., 4 pp, illus., No. 55. How Strain-Tempered bar steel improves such machinery parts as gears. (72)

Finned Tube. Wolverine Tube Div., Calumet & Hecla, Inc. Covers applications for Trufin integrally finned tube in the electrical, refrigeration and allied industries. (73)

Tool, Die Steels. Cannon-Muskegon, Inc., 13 pp, Revision No. 27. Technical data sheets listing composition, physical properties and heat treating of various tool and special purpose steels. Standard designations included. (74)

Enameled Metal Strip. Coated Coil Corp., 4 pp, illus. Describes coiled enameled metal strip supplied in widths up to 30 in. (75)

Leaded Steels. Steel Div., Copperweld Steel Co., 16 pp, illus. Information on characteristics, mechanical properties and workability of leaded steels. (76)

Perforated Steel Sheets. Cross Engineering Co., leaflet, illus. Shows variety of designs available and typical uses of perforated steel sheets for ventilation, concealment, decoration and protection. (77)

Cold Rolled Steel. Crucible Steel Co. of America, 4 pp. Lists warehouse stocks of cold rolled, tempered, polished blued and black oil tempered spring steels. (78)

Stainless, High Alloy Tubing. Trent Tube Co., Div. Crucible Steel Co. of America, 48 pp, illus. Gives applications and physical, chemical and electrical properties for stainless and high alloy tubing. (79)

Welded Stainless Tubing. Damascus Tube Co., 6 pp, illus. Explains how welded stainless steel tubing is manufactured. Provides answers to a number of questions asked about stainless steel tubing. (80)

Pearlitic Malleable Castings. Central Foundry Div., General Motors Corp., 70 pp, illus. Provides engineering data on Armasteel castings, plus machining information. (81)

Steel Tubing. Rochester Products Div., General Motors Corp., 12 pp, illus., No. 271. Typical applications of GM tubing made in both single and double walls of steel. (82)

Perforated Metal Sheets. Harrington & King Perforating Co., Inc., 6 pp, illus. Describes sizes, gages and materials of perforated metal sheets carried in stock. (83)

Screens, Fabricated Metals. Hendrick Mfg. Co., 132 pp, illus. A 75th anniversary catalog on perforated metals, screens and fabricated metals. Typical uses, designs, sizes and engineering data. (84)

Investment Castings. Hitchiner Mfg. Co., 16 pp, illus. Outlines major advantages of both ferrous and nonferrous investment castings. Gives a step-by-step description of the investment casting process. (85)

Metal Powder Parts. Keystone Carbon Co., 6 pp, folder. Describes metal powder products and production facilities. (86)

Precipitation Hardening Steels. Latrobe Steel Co., 6 pp, illus. Properties of Cascade precipitation hardening die steels for plastic molds, zinc die-casting dies and holding blocks. (87)

Steel Castings. Lebanon Steel Foundry, 4 pp, illus. Case histories of two aircraft steel castings made with Lebanon's Ceramicast Process. (88)

Metal Powder Parts. Powdered Metal Parts Div., Lux Clock Mfg. Co., Inc., 12 pp, illus. Case histories show advantages of using metal powder parts. Gives specifications for metal powder parts. (89)

Malleable Iron Castings. Malleable Founders' Society, 8 pp, illus. Discusses machinability, cold forming, impact and corrosion resistance and sizes of malleable iron castings. (90)

Zinc Coated Steel. Weirton Steel Co., Div. National Steel Corp., Weirton, W. Va., 12 pp, illus. Shows advantages of using zinc coated steel in heating,

air conditioning and ventilating applications. Briefly describes its fabrication. Write directly to Weirton.

Steel Fasteners. Nut-Shell Co., 53 pp, illus. Series of specification sheets giving dimensional data, part number, weight, type of material and finish for self-locking, hex, miniature, dome and right angle steel nuts. (91)

Steel Die Forgings. Park Drop Forge Co., 8 pp, illus. Shows company products of closed die forgings made of carbon, alloy, stainless and heat resisting steels in sizes from 5 to 5000 lb. (92)

Steel Wire. Pittsburgh Steel Co., 120 pp, illus. Sizes, tensile strength and chemical composition of approximately 100 types of steel wire are given. (93)

Knitted Wire Products. Riverside Alloy Metal Div., H. K. Porter Co., Inc., 8 pp, illus., No. A-1. Describes design features of knitted stainless steel and nickel alloy wire. (94)

Iron Powder. Pyron Corp., 8 pp, No. 1. Technical information on hydrogen-reduced and electrolytic iron powders. (95)

Welded Steel Tubing. Rome Mfg. Div., Revere Copper & Brass Inc., 12 pp. Discusses electric resistance welded steel tubing, including lengths, special shapes, types of finishes and types of steel. (96)

Metal Stampings. Bossert Div., Rockwell Spring & Axle Co., 8 pp, illus. Describes facilities for producing large, small, light and heavy stampings in any metal or alloy. (97)

Metal Stampings. Dayton Rogers Mfg. Co., 8 pp, illus. Metal stampings available, cost data, and facts regarding company's services are given. (98)

Centrifugal Castings. Sandusky Foundry & Machine Co., 12 pp, illus. Gives specification, chemical composition and physical properties of ferrous and nonferrous metals used in the company's centrifugal castings. (99)

Spring Steels. Sandvik Steel, Inc., 6 pp, illus. Information on type, size, material and chemical composition of spring and specialty strip steels. (100)

Steel Tubing. Tubing Div., Brainard Steel Co. Div., Sharon Steel Corp., 8 pp, illus. Welded mechanical and structural steel tubing, with tables on weight per linear foot, size tolerances and gage tolerances. (101)

Glass Coated Steel. A. O. Smith Corp., 4 pp, illus., No. MQ-101. Describes what glass coated steel is, why it was developed and where it can be used. Shows resistance of glass coatings to several highly corrosive acids. (102)

Metal Stampings. Standard Stamping & Perforating Co., 114 pp, illus. Catalog of standard stamped and perforated patterns. (103)

Welded Tubing. Standard Tube Co., 8 pp, illus. Describes stainless steel pipe and tubing, mechanical steel tubing and boiler, condenser and other pressure tubing. (104)

Stainless Steel. Superior Steel Corp., 8 pp, illus. Gives chemical composition and corrosion resistance data on a boron stainless steel for reactor shielding. Outlines welding, mechanical properties and machinability. (105)

Foundry Products. Superior Steel & Malleable Castings Co., 25 pp, illus. Gives 25 case histories showing products before and after redesigning. (106)

Metal Tubing. Superior Tube Co., 3 pp, No. 1. Gives chemical composition of 121 ferrous and nonferrous metals and alloys used for standard and special small diameter tubing. (107)

Constructional Alloy Steel. U. S. Steel Corp., illus. Gives properties and fabrication data for high strength, weldable steel. (108)

Welded Tubing. Van Huffel Tube Corp., 32 pp. Covers sizes, gages and tolerances of square, round and rectangular steel tubing and special cold formed shapes. (109)

Stainless Steel Tubing. Wallingford Steel Co., 8 pp, illus. Describes stainless, carbon and alloy steel tubing for ornamental, mechanical, pressure, sanitary and aircraft uses. (110)

Stainless Steel. Washington Steel Corp., 28 pp, illus. Gives physical properties, chemical composition, corrosion resistance, surface characteristics, fabrication, specifications and availability of a nickel-free stainless steel called Microrold 430. (111)

Metal Stampings. Worcester Pressed Steel Co., 8 pp, illus. Company facilities for custom metal stamping. (112)

Continuous Weld Pipe. Youngstown Sheet & Tube Co., 2 pp. Folder gives complete data on Yoloy continuous weld standard pipe and line pipe, including its corrosion resistance. (113)

Gray Iron Castings. Zenith Foundry Co., 20 pp, illus. Shows how quality control is used in the production of gray and alloy iron. Includes physical properties of gray and alloy irons. (114)

Nonferrous Metals • Parts • Forms

Aluminum Forgings. Aluminum Co. of America, 18 pp, illus. Briefly discusses heat treatments, testing procedures, identification and marking, machining, dimensions and pricing of aluminum hand forgings. (122)

Engineering Bronzes. American Crucible Products Co., 12 pp, illus. Gives case histories and applications of Promet bronzes. (123)

Bearing Bronze. Continuous-Cast Products Dept., American Smelting & Refining Co., 6 pp, illus., No. 301. Gives continuous-cast stock sizes and weights for solid and hollow bronze bars ½ to 9 in. in dia. (124)

Nonferrous Castings. Atlantic Casting & Engineering Corp., 12 pp, illus. How to obtain nonferrous castings cast to ordinary machining tolerances. Describes process and gives alloy specifications. (125)

Magnesium, Aluminum Castings. Eclipse-Pioneer Div., Bendix Aviation. Shows company's facilities for making aluminum and magnesium castings. (126)

To get manufacturers' literature use prepaid post card on pp 71 and 72.

Bimetals. W. M. Chace Co., 36 pp, illus. Describes and explains 22 uses of bimetals as actuating elements in temperature responsive devices. (127)

Titanium. Rem-Cru Titanium, Inc., 12 pp. Data sheet on Rem-Cru C-130 AM titanium. (128)

Resistance Alloys. Driver-Harris Co., 8 pp, illus. Four bulletins describe an 0.0005-in. dia enameled wire for resistors; an alloy with a specific resistance of 1000 ohms per cmf; a new heating element alloy; and a new oxidation resistant thermocouple for high temperatures. (129)

Titanium. Pigments Dept., E. I. du Pont de Nemours & Co., Inc., 8 pp, illus. Up-to-date data on properties of titanium and methods of fabricating the metal. (130)

Embossed Aluminum. Fairmont Aluminum Co., 4 pp. Lists patterns, forms, tempers, thickness ranges and widths of embossed aluminum. Contains actual samples. (131)

Metal Powder Parts. Supermet Div., Globe Industries, Inc., 8 pp, illus. Design information on Supermet metal powder process. (132)

Zinc Die Castings. Gries Reproducer Corp., 8 pp, illus. Design information and physical data on zinc alloys for die castings. (133)

Copper and Brass Tubing. H & H Tube & Mfg. Co. Describes a complete line of seamless braze and lock seam copper and brass tubing. (134)

Brass, Aluminum Parts. Hampden Brass & Aluminum Co., 24 pp, illus. Information on brass and aluminum castings. Shows foundry operations, inspection and testing. (135)

Aluminum Structures. Harvey Aluminum Sales Inc., 12 pp, illus. Facilities, company history, and structural applications for aluminum extrusions. Mechanical properties and a comparison of aluminum and steel sections are presented. (136)

Laminated Shims. Laminated Shim Co., Inc., 8 pp, illus. Outlines types, tolerances, construction, and uses of laminated shims made of brass, steel, aluminum and stainless steel. (137)

Laminated Metals. General Findings & Supply Co., and Leach & Garner Co., 8 pp, illus. Outlines sizes and forms of precious and laminated metals for the electronic, aircraft and automotive industries. (138)

Extruded Aluminum. Light Metals Corp., 6 pp. Illustrates such extruded aluminum parts as trim, glass frames and supports. (139)

Contact Materials. General Plate Div., Metals & Controls Corp., illus. Catalog on solid and clad precious and base metals, industrial metals, electrical contacts, contact parts and assemblies. (140)

Phosphor Bronze. Rolling Mill Div., Miller Co., 4 pp, illus. Outlines advantages and properties of phosphor bronze products. (141)

Aluminum Bronze. Mueller Brass Co., 7 pp, illus. Chemical and mechanical properties and uses of Tuf-Stuf, high copper base alloys. (142)

Aluminum Core. Narmco Resins &

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Nonmetallic Materials • Parts • Forms

Coatings Co., 6 pp. Formable core material for aluminum sandwich constructions where small-radius curves are needed. (143)

Nonferrous Powder Parts. New Jersey Zinc Co., 4 pp, illus. Advantages of nonferrous powder parts in product engineering with emphasis on brass powder parts. (144)

Die Castings. Parker White Metal Co. Engineering data on die cast component parts. (145)

Aluminum Castings. Permold Co., illus. Shows how continuous scientific control of aluminum casting quality saves time and money. (146)

Small Tubing. Precision Tube Co., Inc., 4 pp, illus., No. 3. Information on shape, size, temper, dimensional tolerances and finish of small diameter tubing (⅞ to 0.010 in. o.d.). (147)

Aluminum. Reynolds Metals Co., 6 pp, illus. Graphs show yearly corrosion rates of more than 100 chemicals on aluminum. (148)

Metal Patterns. Rigidized Metals Corp., 4 pp, illus., *Rigid-Tex Metal News*, No. 3. Briefly discusses advantages and applications of metal patterns. (149)

Roll Formed Shapes. Roll Formed Products Co., 26 pp, illus. Shows simple and complex sections produced from both ferrous and nonferrous metals. (150)

Aluminum, Magnesium Castings. Rolle Mfg. Co., 58 pp, illus. Gives design information and properties of aluminum and magnesium sand, permanent mold and die castings. (151)

Copper Alloy. Seymour Mfg. Co., 40 pp, illus. Extensive technical data on nickel silver and phosphor bronze, as well as cleaning and annealing information. (152)

Electronic Materials. Tungsten & Chemical Div., Sylvania Electric Products, Inc. Series of data sheets on tungsten, molybdenum, semiconductor, plated wire, chemical and phosphor products. (153)

Brass, Bronze, Aluminum Forgings. Titan Metal Mfg. Co., 32 pp, illus. Design, properties and applications of brass, bronze and aluminum hot pressed forgings. (154)

Flame Cutting Aluminum. Linde Air Products Co., Union Carbide Corp., 4 pp, illus. Describes a process for flame cutting of aluminum. Illustrations show ½-in. thick aluminum cut into round, square and beveled edge pieces. (155)

Copper-Base Castings. Waukesha Foundry Co., 8 pp, illus. Contains suggested applications, physical properties, chemical composition and advantages of a line of copper-base, high nickel castings. (157)

Plastics Products. American Agile Corp., 4 pp, illus. Outlines properties and uses of a line of molded, cemented, and welded plastics valves, sheets, blocks, rods, pipe and fittings. Information also on how to weld and spray plastics. (165)

Molding Compound. American Cyanamid Co., 6 pp. Technical data on glass fiber - filled melamine - formaldehyde molding material. (166)

Rayon for Filters. American Viscose Corp., 3 pp, illus. Shows advantages of rayon filters in smoke, air and liquid filtration. (167)

Foamed-In-Place Resins. Isocyanate Products, Inc., 4 pp. Advantages; electrical, thermal and mechanical properties; applications; and directions for use of IPI-Isofoam, a new foamed-in-place polyisocyanate expansible resin. (168)

Zirconium. Metals Div., Carborundum Co., 8 pp, illus. *More Zr Facts*, Vol. 1, discusses the corrosion resistant properties of zirconium. (169)

Clear Rigid Plastics. Cast Optics Corp., 12 pp, illus. Lists uses, advantages and properties of five optically clear rigid plastics sheets. (170)

Rubber Products. Castle Rubber Co., 4 pp, illus. Information on molded and lathe-cut rubber products, roll coverings, and rubber-to-metal bonding done to customer specifications. Outlines types of rubber used in each product. (171)

Injection Molding Cellulosics. Plastics Div., Celanese Corp. of America, 7 pp, illus. No. A-16 "Fundamentals of Injection Molding Cellulosics." (172)

Coated Fabrics. Connecticut Hard Rubber Co. Uses; chemical, electrical and mechanical properties; and availability of heat resistant, silicone rubber-coated glass fabrics. (173)

Felt. Continental Felt Co., Inc., 10 pp, illus. A history of felt and a description of some of its uses in machinery. (174)

Plastics Pipe, Fittings. Corning Glass Works, No. PE-40. Physical properties, uses and specified dimensions of PVC pipe and fittings. (175)

Nylon Products. Danielson Mfg. Co., 4 pp, illus. Discusses extruded nylon shapes such as solid rod, tubing, tape and pipe. Information on nylon parts for marine applications. (176)

Urethane Foams. Dayton Rubber Co., 14 pp, illus. Briefly describes electrical, mechanical and thermal properties of urethane foams. Charts show aging, compression and stress-strain properties. (177)

Rubber - to - Metal Parts. Metalastic Corp. of America Div., Dayton Rubber Co., 8 pp, illus. Shows use of rubber-to-metal parts in automobiles, medium and heavy duty machinery, and railroad cars. (178)

Electric Motor Insulation. Dobeckmun Co., 4 pp, illus. Mylar, cellulose acetate and electrical papers for electric motor slot cell insulation, phase separation and laver insulation. (179)

Thermoplastics. Plastics Dept., Dow Chemical Co., 20 pp, illus. Properties of Styron, Ethocel, Saran and vinyl supplied by Dow. (180)

Tank Lining. Fabrics Div., E. I. du Pont de Nemours & Co., Inc., 8 pp, illus. Information on a precured isobutylene tank lining. Outlines chemical, abrasion, heat and ozone resistance of the material. (181)

Polyester Film. Film Dept., E. I. du Pont de Nemours & Co., Inc., 8 pp, illus. Latest commercial uses and detailed physical and chemical properties of Mylar. (182)

Plastics for Lighting. Polychemicals Dept., E. I. du Pont de Nemours & Co., Inc., 11 pp, illus. Properties of Lucite acrylic resin and applications involving indoor and outdoor lighting. (183)

Plastics Products. Dura Plastics, Inc., 8 pp, illus. Describes and illustrates a number of products fabricated from thermoplastic sheets, rods and tubes, including Plexiglas, Lucite, Teflon, Nylon, Kel-F and Royalite. (184)

Cellulose Ester Plastics. Eastman Chemical Products, Inc., 44 pp. Properties and uses of various types of "Tenite" cellulose ester plastics. (185)

Fiberglass Ducts. Arrowhead Products Div., Federal-Mogul-Bower-Bearings Inc., 16 pp, illus. Information on Airtron fiberglass ducts, sleeves and couplings. Describes five basic types and shows typical applications. (187)

Injection Molding Compound. Fiberfil, Inc., 4 pp. Physical, electrical and chemical properties and uses of Fiberfil Styrene G and Nylon G glass-reinforced injection molding compounds. (188)

Synthetic Latex. Synthetic Rubber & Latex Div., Firestone Tire & Rubber Co., 8 pp, illus. Properties of hot and cold type synthetic rubber latices. (189)

Printed Circuit Materials. Formica Corp., 16 pp, illus. Covers the subjects of plated circuits, plating through holes, flush circuit production and circuit fabricating. (190)

Ceramics. Frenchtown Porcelain Co., 7 pp, illus., No. 955. Quality control and production methods are pictured and a properties chart is included. (191)

Silicone Selector. Silicone Products Dept., General Electric Co., 4 pp, illus., No. AA 24 E. Lists major categories and properties of silicone compounds. Cross references to AMS and ASTM specifications are included. (192)

Plastic-Faced Plywood. Georgia-Pacific Co., 14 pp, illus. Advantages of GPX plastic-faced plywood, used for cabinets and industrial counters. (193)

Rigid PVC. B. F. Goodrich Chemical Co., 8 pp, illus. How rigid unplasticized polyvinyl chloride compounds Geon 8700-A and 8750 are used in making rigid vinyl pipe and fittings. (194)

Synthetic Rubber. Goodrich-Gulf Chemicals, Inc., 24 pp, illus. Discusses compounding and vulcanization of a line of cold non-oil and oil-extended polymers and hot polymers. (195)

Impregnated Graphite. Graphite Metallizing Corp., 64 pp, illus., No. 3. Gives dimensional data, properties and specifications of Babbitt metal and copper-impregnated graphite bushings. (196)

Graphite. Graphite Specialties Corp., 4 pp, No. GS-101-1. Gives chemical and physical properties of an impervious graphite, more than 99.5% pure carbon, for high temperature parts. (197)

Insulating Material. Reinforced Plastics Div., Hays Mfg. Co., 12 pp, illus., No. 100. Properties of Haysite, a glass-reinforced alkyd-base polyester insulating material designed to meet rigid electrical standards. (198)

Thermosetting Plastic. Homolite Corp., 4 pp, illus., No. 1052. Describes a clear thermosetting plastic sheet material which combines light weight with high optical and mechanical properties. (199)

Polyester Resins. Durez Plastics Div., Hooker Electrochemical Co. Data sheets on fire resistant polyester resins. (200)

Glass Fiber Roving. L.O.F. Glass Fibers Co., 8 pp, illus. Properties and specifications of Garan, Vitron and chrome roving for rod stock, molding compounds, preforming, mat, woven roving and other applications. (201)

Zirconia Ware. Laboratory Equipment Corp., 10 pp, illus. Gives characteristics, chemical and physical properties, and porosity of zirconia. (202)

Plastics Laminate. Plexton Dept., G. B. Lewis Co., 4 pp, illus. Properties and uses of a plastics laminate made of fibrous materials and polyester resins. (203)

Mica Insulation. Mica Insulator Co., 12 pp, illus. Gives physical and electrical properties of Isomica insulating material and Samica sheet mica and Isomica tapes and tubes. (204)

Glass-Reinforced Plastics. Molded Fiber Glass Co., 16 pp, illus. Lists fabricating operations and mechanical, electrical and chemical properties of molded fiberglass. (205)

Plastics Materials. Plastics Div., Monsanto Chemical Co., 12 pp, illus. Fabricating data on styrene, polyethylene, phenolic, melamine, vinyl, cellulose acetate and cellulose nitrate. (206)

Carbon Specialties. Morganite, Inc., 12 pp, illus. Data on carbon specialties, including chemical and physical properties, and typical blank sizes and parts. (207)

Glass-Bonded Mica. Mycalex Corp. of America, 24 pp, illus. Gives physical, electrical and thermal properties, and discusses molding, machining, and dimensional tolerances of ceramoplastics and glass-bonded micas. (208)

Zirconia. Titanium Alloy Mfg. Co. Div., National Lead Co., 14 pp, illus. Describes stabilized zirconia powder for ceramics, refractories, insulation and abrasives. Includes chemical and physical properties. (209)

Carbon Parts. Ohio Carbon Co., 4 pp, illus. Thermal, mechanical and electromechanical properties of carbon parts. (210)

Glass-Reinforced Plastics. Textile Products Div., Owens-Corning Fiberglas Corp., 24 pp, illus.. No. PR6.Al. Physical, mechanical, chemical and electrical properties of fiberglass-reinforced alkyd, polyester, melamine, polystyrene and phenolic resins. Briefly describes eight molding procedures for fabricating fiberglass-reinforced plastics. (211)

Custom Molded Rubber Parts. Rubber Products Div., Parker Appliance Co., 4 pp, illus., No. 5810. Describes compounding service for custom molded rubber parts. (212)

Polystyrene Patterns. Precision Metalsmiths, Inc., 4 pp. Guide for making polystyrene patterns. Describes machining procedures and gives sources for materials. (213)

Corrosion Resistant Gasketing. Products Research Co., 5 pp, illus. Features advantages and specifications of Chromelock corrosion resistant gasketing material. (214)

Carbon Graphite. Pure Carbon Co., Inc., 12 pp, illus., No. 55. Catalog on carbon graphite for mechanical applications. (215)

Wood Particle Products. Reichhold Chemicals, Inc., 8 pp, No. G-9. Gives processing information and economic data on wood particle products. Outlines manufacturing methods, plant investment and production costs. (216)

Gasket Materials. Rogers Corp., 13 pp, illus. Forms available, and physical and chemical properties of a line of gasketing materials for electrical insulation, gaskets and filters. (217)

Rubber. Roth Rubber Co., 1860 S. 54 Ave., Chicago, Ill. Rubber Sampler No. MM3. Actual rubber samples with hardness from 5 to 100 durometer. Write directly to Roth.

Laminated Plastics. Panelyte Div., St. Regis Paper Co., 19 pp, illus., No. 1-d-PA. Industrial, chemical and decorative applications of Panelyte structural laminated resinous plastics. (218)

Impervious Graphite. National Carbon Co., Union Carbide Corp., 4 pp, No. S-5050. Gives recommendations for applying "Karbate" impervious graphite and "National" resin-base cements to parts used in corrosive service. (219)

Tetrafluoroethylene. U. S. Gasket Co., No. 300. Tables and descriptive matter on chemical, electrical, thermal and mechanical properties of Teflon. (220)

Porcelain-Faced Plywood. U. S. Plywood Corp., 6 pp, illus. Describes Weldwood Porc-Lin-Ply panels. Shows colors available and gives typical applications, installation instructions and specifications. (221)

PVC Resins. Naugatuck Chemical Div., U. S. Rubber Co., 4 pp. Gives description, special features and resin and compound properties of general purpose, extrusion, calendering, and electrical grade polyvinyl chloride resins. (222)

Plastics Pipe. National Tube Div., U. S. Steel Corp., 28 pp, illus., No. 24. Data on unplasticized rigid polyvinyl chloride pipe, both normal and high impact types. (223)

High Temperature Ceramics. Alite Div., U. S. Stoneware Co., 7 pp, No. A-7. Describes physical and high temperature properties, methods of joining and electrical characteristics of Alite, a sintered aluminum ozide used in high temperature applications. (224)

Synthetic Rubber Products. Acadia Synthetic Products Div., Western Felt Works, 6 pp, illus. Shows various types of molded, extruded die cut and lathe cut synthetic rubber parts and sheets. (225)

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Finishes • Cleaning & Finishing

Ultrasonic Cleaning. Pioneer Central Div., Bendix Aviation Corp., 8 pp, illus. Folder describes ultrasonic cleaning process and equipment. (237)

Metallic Coatings for Plastics. Coating Products. Attractive brochure describes the various coatings applied to plastics materials. Samples included. (238)

Painting Machine. Conforming Matrix Corp., 1 p, illus. Describes an automatic painting machine developed especially for spray finishing of cylindrical and rectangular parts such as bottles and tubes. (239)

Vapor Spray Degreasers. Detrex Chemical Industries Inc., 4 pp, illus. Describes open top degreasers for pure vapor degreasing, spray flushing with oil-free solvent distillate and final pure rinse. (240)

Diamond Abrasive. Abrasives Div., Elgin National Watch Co., 4 pp, illus. Describes Dymo-C, a diamond abrasive for finishing carbide dies. (241)

Solution Coating Resin. Firestone Plastics Co., 8 pp, No. 13. Properties and uses of Exon 450 vinyl chloride copolymer resin for solution coatings, either permanent or strippable. (242)

Bright Nickel Plating. Scientific Div., Harshaw Chemical Co., 4 pp, illus. Advantages of Nubrite bright nickel plating process. (243)

Multicolor Enamel. Maas & Waldstein Co., 2 pp, No. 520. Data sheet for industrial multicolor enamels. (244)

Zinc Coatings. Metallizing Engineering Co., Inc., 4 pp, illus. Description of Metco Systems and how these pure metallized zinc or aluminum coatings prevent corrosion. (245)

Protective Coatings. Michigan Chrome & Chemical Co., 8 pp, illus. Describes coating materials for tanks, molds and fixtures used in plating systems. (246)

Silicone-Base Finish. Midland Industrial Finishes Co. Brochure describes silicone-base finish said to resist heat at 500 F without discoloration. (247)

Paint Stripper. Northwest Chemical Co., 1 p. Describes a chemical stripper for removing paint and other organic finishes from steel, magnesium and zinc castings. (248)

Optical Coatings. Optical Coating Laboratory, Inc., 14 pp, illus. Information on a number of specialty optical coatings. Shows company production and testing facilities. (249)

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Porcelain Enamel. Porcelain Enamel Institute, 30 pp, illus. Outlines types, uses and properties of porcelain enamel coatings. Included is a glossary of terms used in porcelain enameling. A table lists various testing methods. (251)

Electrostatic Spray Painting. Ransburg Electro-Coating Corp., 16 pp, illus. Typical on-the-line examples of the Ransburg No. 2 process of electrostatic spray painting. (250)

Methods & Equipment

Welding Electrodes. Air Reduction Co., Inc., 70 pp, illus., No. ADC 650 G. Provides data for calculating electrode consumption per linear foot in the welding of various types of joints. Gives specifications, color codes, uses and properties of a line of low alloy, mild and stainless steel electrodes. (260)

Martempering. Ajax Electric Co., 2 pp, illus., No. 164. "Deepest Martempering Furnaces Cut Distortion on Aircraft Weldments." (261)

Low Temperature Cabinet. Alpha Electric Refrigeration Co., 4 pp, illus. Gives sizes, operational data and advantages for a line of low temperature cabinets. Information on cold treating as a time saving aid in producing machine tools, bearings and aircraft parts. (262)

Heat Treat Pots. Electro-Alloys Div., American Brake Shoe Co., 6 pp, illus. Gives pattern number, weight, wall thickness, depth, and diameter of round and rectangular heat pots made of Thermalloy. (263)

Hardness Testing. Wilson Mechanical Instrument Div., American Chain & Cable Co., Inc., 12 pp, illus., No. DH-328. Describes Tukon Testers for micro and macro hardness testing. (264)

Silver Brazing. American Platinum Works, 16 pp. Manual on selective fluxing for low temperature silver brazing. (265)

Springs. Associated Spring Corp., 8 pp, illus., No. 17. Outlines causes of spring failures and shows how to correct them. Shows the use of springs in cameras, toys, fishing equipment, record players and guns. (267)

Spectrograph. Bausch & Lomb Optical Co., 14 pp. Describes a 1.5-m stigmatic spectrograph for laboratory use. (268)

Electropolisher. Buehler Ltd., 8 pp, illus., Vol. 3 No. 4. Discusses the operation of a new electropolisher for use in metallographic electropolishing. Illustrates and describes polishing and etching accessories. (269)

Tamper-Proof Screws. Central Screw Co., 4 pp, illus. Gives style numbers, specifications and features of hand and power driven screws that are said to make most assemblies tamper-proof. Shows where the screws may be used, such as outdoor theater speaker units and cameras. (270)

Iron Powder Electrodes. Champion Rivet Co., 8 pp, illus. Lists current ranges, mechanical properties and deposition rate of four iron powder electrodes for rutile, low hydrogen, rutile fillet and low hydrogen arc welding. (271)

Ultrasonic Inspection. Industrial & Scientific Products Div., Curtiss-Wright Corp., 4 pp, illus. Discusses ultrasonic testing and how it may be applied to materials inspection. (272)

Sintering Furnaces. Drever Co., 12 pp, illus., No. B-101. Describes furnaces for sintering metal powder products. (273)

Grooved Fasteners. Driv-Lok Pin Co., 24 pp, illus. General specifications of grooved fasteners, as well as drilling procedures and hole tolerances for pin applications. Typical applications for various types of fasteners. (274)

Projection Gaging. Eastman Kodak Co., 12 pp, illus. Describes four models of a contour projector and their accessories for inspection usage. (275)

Bridge Amplifier Meter. Ellis Associates, 2 pp, illus., No. 6. Describes BAM-1 bridge amplifier and meter that measures strain, stress load acceleration pressure and vibration displacement. (276)

Welding Methods. Eutectic Welding Alloys Corp., 8 pp, illus., No. TIS-2836A. Information on methods for welding crack sensitive and heat treatable steels, and iron, aluminum and magnesium castings. Tells how to hard surface and case harden metals for long productive life. (277)

Friction or Damper Parts. World Bestos Div., Firestone Tire & Rubber Co., 4 pp, illus., No. 648. Available molded parts—brake linings and blocks, transmission linings, clutch facings and thrust washers. (278)

Welding Rod Coatings. Foote Mineral Co., 20 pp, illus. Discusses the function and use of columbium, manganese, silicon, titanium and vanadium ferro-alloys as coatings for welding electrodes. Information on flux and slag forming materials. (279)

Temperature Controls. Claude S. Gordon Co., 4 pp, illus. Brief description and advantages of a straight line, fully automatic temperature control. (280)

Lock, Weld and Clinch Nuts. Grip Nut Co., 12 pp, illus. Specifications and applications for Gripco fasteners. (281)

Heat Treating. C. I. Hayes, Inc., 4 pp, illus. Discusses laboratory and production facilities for solving heat treating problems. (282)

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Heat Treating Furnaces. Lindberg Engineering Co., 8 pp, illus., No. 250. Describes various types of heat treating furnaces, including tempering and controlled atmosphere hardening furnaces. (283)

Inspection Instrument. Micrometrical Mfg. Co., 4 pp, illus. Gives specifications, uses and features of an instrument used for measuring and recording surface profiles and flaws in various materials. (284)

Rivets. Milford Rivet & Machine Co., 12 pp, illus. Gives specifications, applications and design tips for a series of cold formed rivets furnished in semi-tubular and split rivet types. (285)

Self-Locking Bolts. National Machine Products Co., 8 pp, illus. Gives principles of operation, engineering standards and tightening information for a series of self-locking bolts. Shows typical applications. (286)

Modern Testing. Tinius Olsen Testing Machine Co., 25 pp, illus. Traces major advances in design of testing and balancing equipment since 1880. (287)

Window, Door Parts. Security Companies, 12 pp, illus. Information on a line of roll formed aluminum window and door components. Information also on vinyl glazing and weather stripping and metal lock assemblies and hinges. (288)

Quality Control. Spectrochemical Laboratories, Inc., 4 pp, illus. Information on quantometric, spectrographic and wet chemical analysis of ferrous, nonferrous and nonmetallic materials. (289)

Aircraft Bolts. Standard Pressed Steel Co., 8 pp, illus. Compares the fatigue strength of National Aircraft Standards 624 series high strength bolts with the company's line of aircraft bolts made to military specifications. Charts and graphs show sizes and mechanical properties of the bolts. (290)

Vacuum Processing. F. J. Stokes Machine Co., 12 pp, illus., No. 790. Explains use of high vacuum furnaces. Also lists typical metals processed in the vacuum furnace and shows effects of vacuum furnace processing on alloy metals. (291)

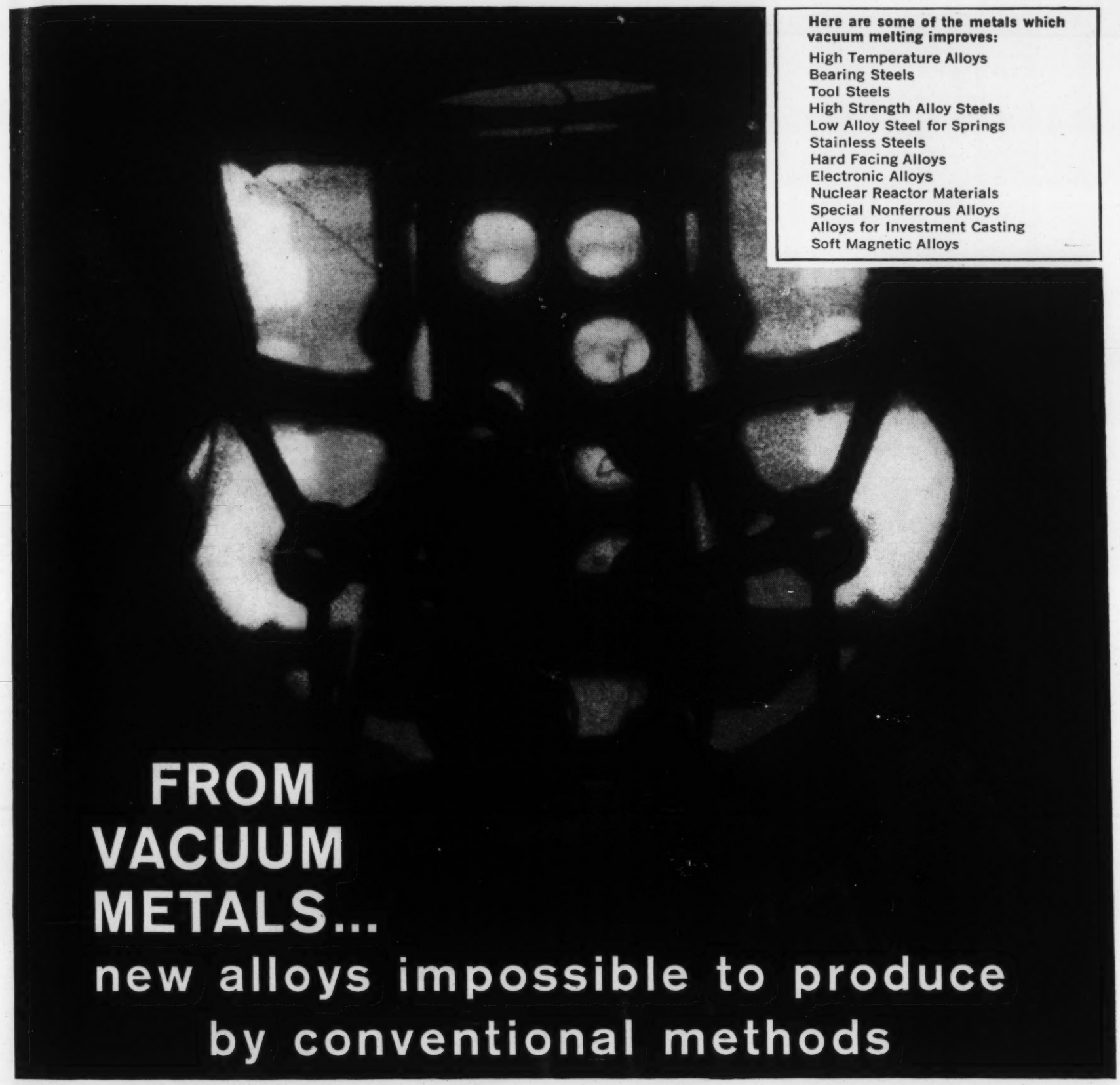
Rivet. Cherry Rivet Div., Townsend Co., 4 pp, illus., No. TCL-112. Advantages and operating principles of the Cherry "700" rivet. Lists head styles, diameters and lengths. (293)

Ultraviolet Light. Ultra-Violet Products, Inc., 1 p, illus. Describes an ultraviolet light for chromatography and laboratory research. (294)

Heat Treating Furnaces. Industrial Heating Dept., Westinghouse Electric Corp., 38 pp, No. B-5459. Describes large and small gas and electric furnaces. (295)

Perforating Dies. S. B. Whistler & Sons, Inc., 24 pp, illus., No. 55. Catalog of adjustable perforating dies. Lists sizes, shapes, applications and punching pressures. (296)

Electric Heaters. Edwin L. Wiegand Co., 4 pp, illus., No. 850. Discusses electric cartridge heaters for dies, platens and molds. (297)



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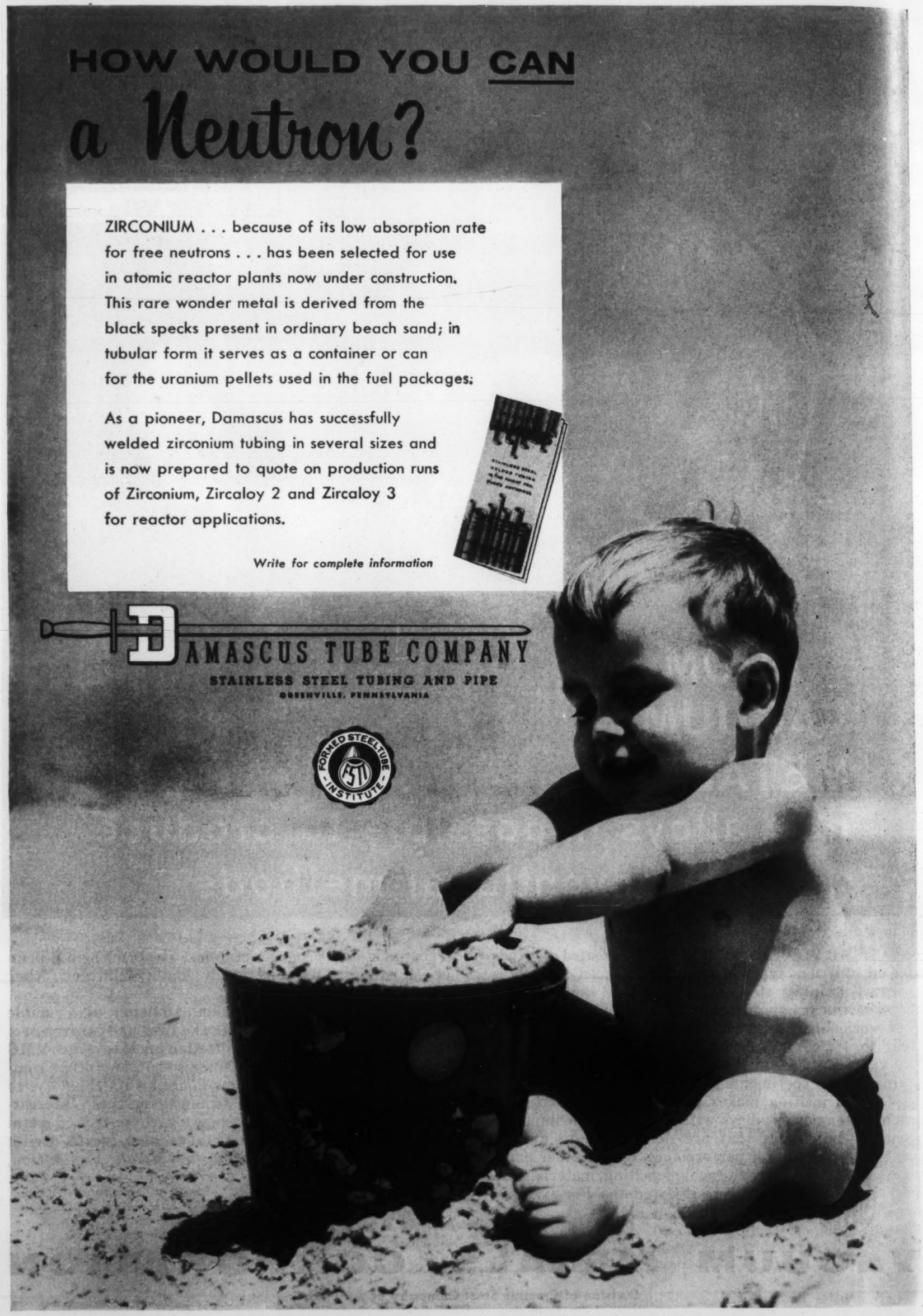

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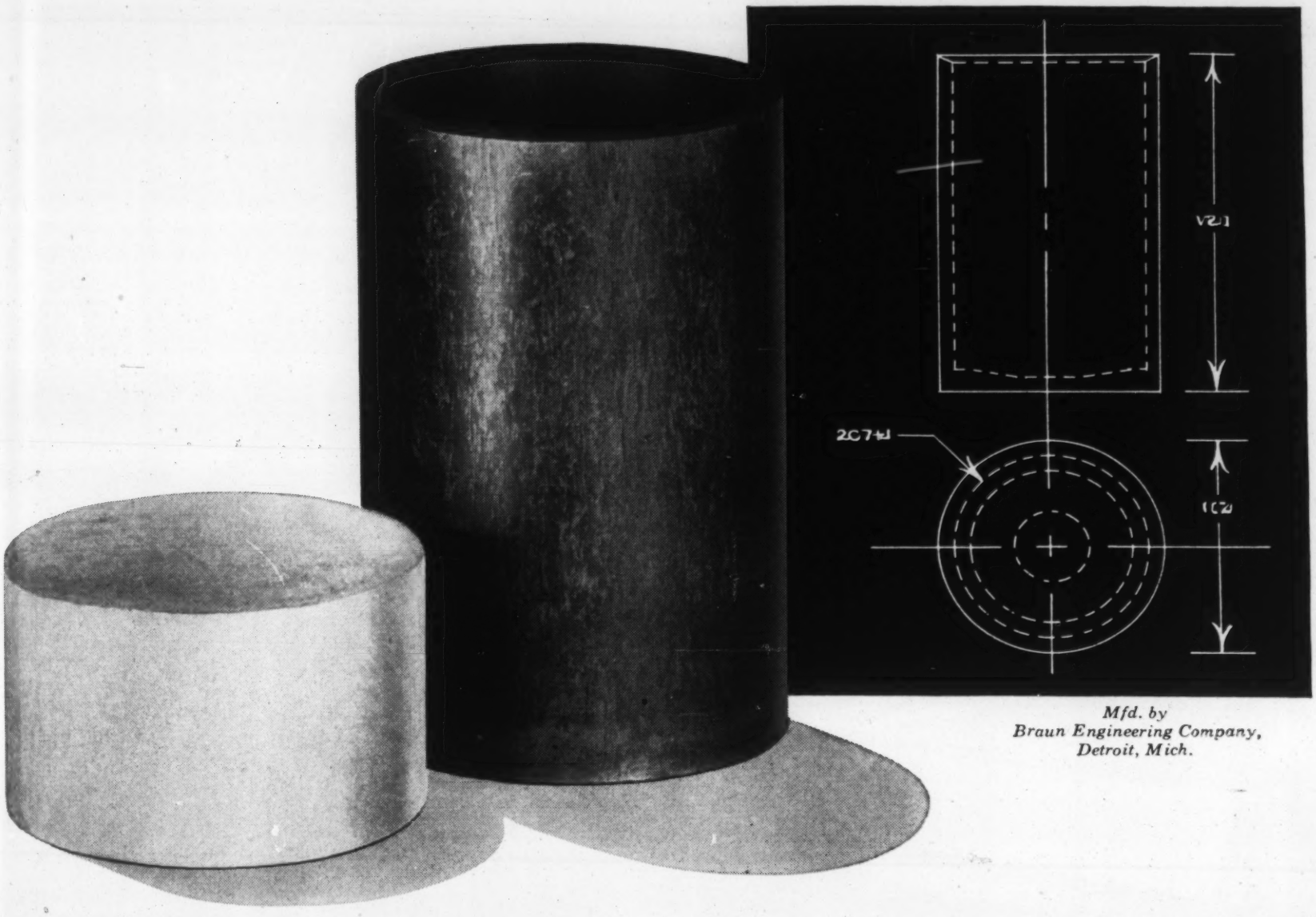

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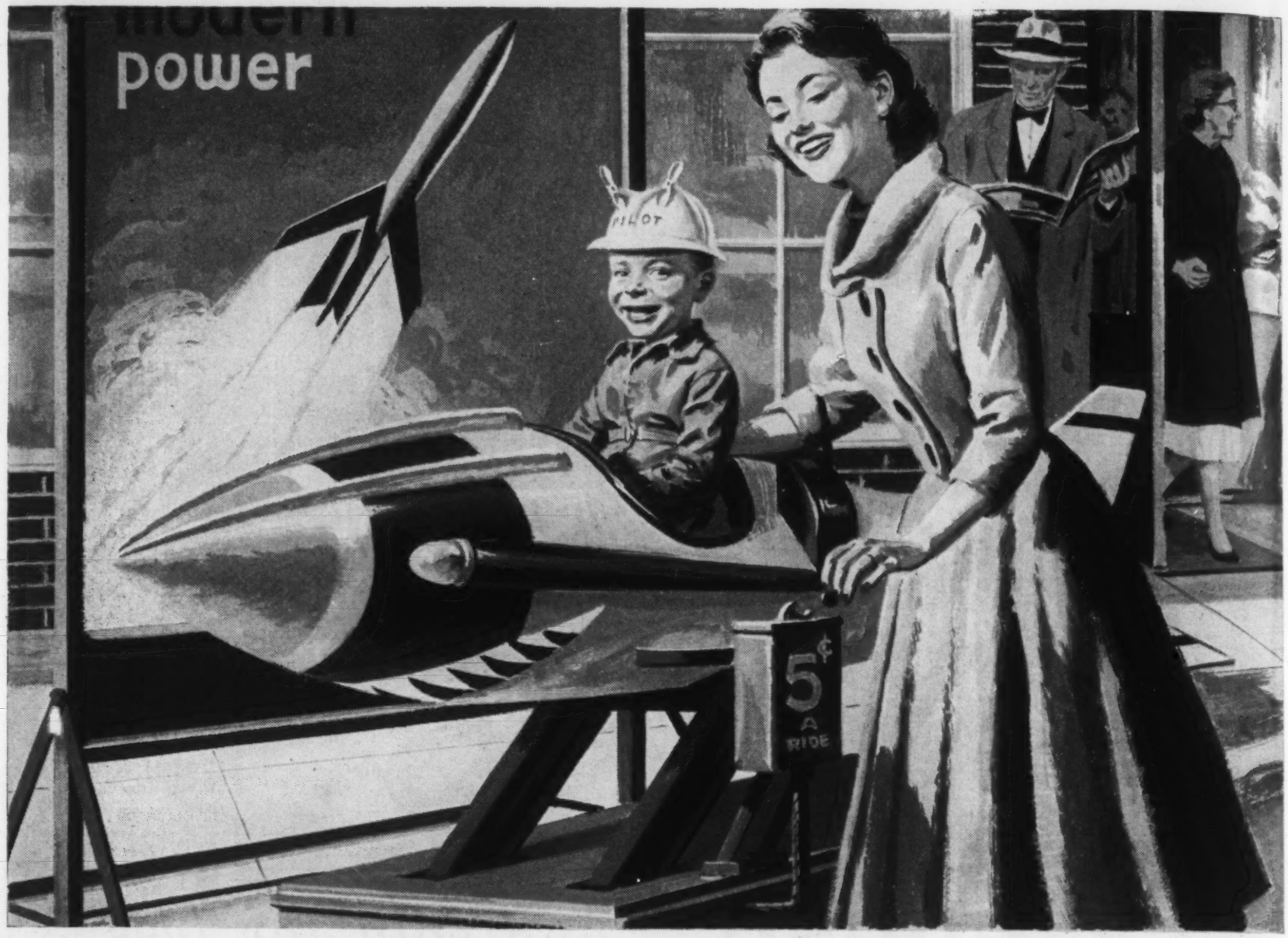


It Takes "A" Nickel to Make It Fly

Superior "A" nickel tubing with close tolerances and excellent properties helps today's rockets and missiles soar many miles out into the stratosphere

Superior "A" nickel tubing and many other components for these rockets and missiles are first tested extensively under the most demanding conditions engineers can devise. Tubing of "A" nickel has proved itself to have these important qualities:

- **High corrosion resistance**
- **Strength retained at extremely hign and low temperatures**
- **Ability to accept unusually severe fabrication**
- **Excellent heat transfer properties**
- **Unchanging properties during storage**

Superior has long been one of the outstanding suppliers of aircraft quality tubing in a broad range of analyses, all produced to rigid specifications. Another example is Superior stainless hydraulic tubing, which is but one of our many tubing products being used by major aircraft manufacturers.

Make Superior *your* source of supply. We can furnish you with the finest quality small tubing obtainable anywhere. Our staff of engineers and specialists stands ready to work with you on any tubing problems of engineering or design.

For technical data on nickel and nickel alloy tubing, write us for Catalog 12. For latest information on stainless tubing, ask for Catalog Section 21. Superior Tube Company, 2006 Germantown Ave., Norristown, Pa.

Superior Tube

The big name in small tubing

NORRISTOWN, PA.

All analyses .010 in. to ⅝ in. OD—certain analyses in light walls up to 2½ in. OD

West Coast: Pacific Tube Company • 5710 Smithway St., Los Angeles 22, Calif. • RAymond 3-1331

For more information, turn to Reader Service card, circle No. 553

This alloy "shopping list" saves many a day for busy metallurgists!

AISI		AMS			SAE	
302	410	5333	5376	5631	30302	51442
303	414	5334	5378	5640	30303	51446
304	416	5350	5380	5643	30303F	60303A
308	420	5351	5382	5645	30304	60304
309	430	5352	5385	5665	30310	60310
309+W	430F	5354	5386	5700	30316	60316
310	431	5355	5388	5710	30321	60347
316	431A	5358	5389	5735	30347	60410
321	436	5360	5392	5765	51410	60420
327	440A	5361	5393	6270F	51414	60442
329	440B	5362	5394	6274F	51416F	60446
330	440C	5363	5526	6280C	51420	70310
331	440F	5366	5537	6350	51430	70310A
347	442	5369	5610E	6382	51431	70327
403	446	5370	5616	6428	51440A	70330
406		5372	5621	7834	51440B	70331
		5373	5628		51440C	70446
		5375	5630		51440F	

MISCELLANEOUS

Armco 17-4PH • GMR 235 • Inconel* • Invar • Monel* • NiResist* IA • NiResist* IIA • NiResist* III • Waspalloy

*® International Nickel Co.

You name the alloy... we'll produce to your specs. —in record time!

THE watchword of CANNON-MUSKEGON is "CONTROL." Careful selection of the finest raw materials . . . rigid melting procedures . . . complete chemical and physical testing facilities, plus closely supervised handling — produce alloys to your most exacting standards. More than 100 special and standard alloy analyses are produced each year.

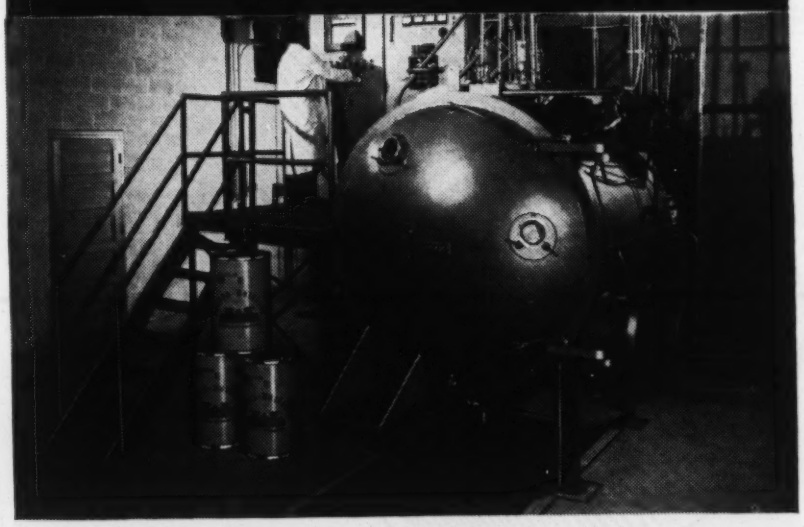
The alloy list above is typical of production "regulars" for scores of users in all industrial fields. If you don't see what you need — remember, our facilities are open to "tailor" alloys to your specific needs. We'll also recommend proper in-plant handling and heat treating procedures to assure the desired physical and chemical properties in your final product.

FOR IMMEDIATE REFERENCE — write for your personal copy of Cannon-Muskegon's 6-page handbook for metallurgists, giving you data on both UltraMet and MasterMet alloy service.

ULTRAMET — VACUUM-MELTED ALLOYS FOR INDUSTRY

MASTERMET — CERTIFIED ALLOYS FOR INDUSTRY

and CANNON-MUSKEGON offers you both vacuum and air-melting facilities for cobalt-, ferrous- and nickel-base alloys in a wide variety of cast forms



UltraMet alloys are produced in this latest design vacuum melting furnace — production center for a virtually unlimited variety of high temperature, corrosion resistant alloys for severe-stress applications.

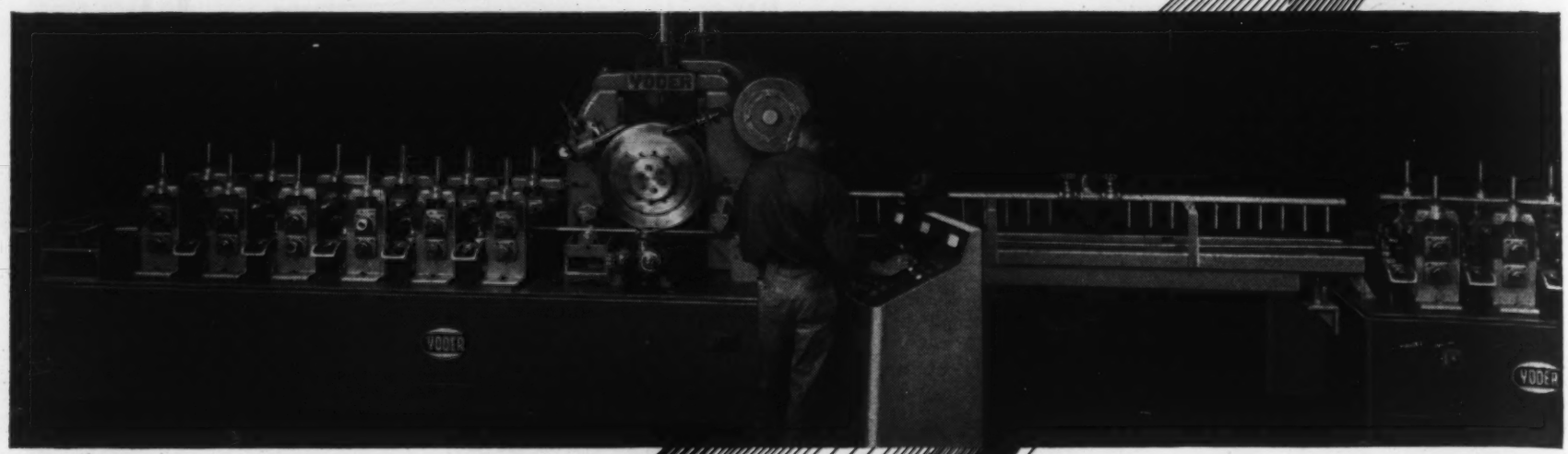
CANNON-MUSKEGON CORPORATION

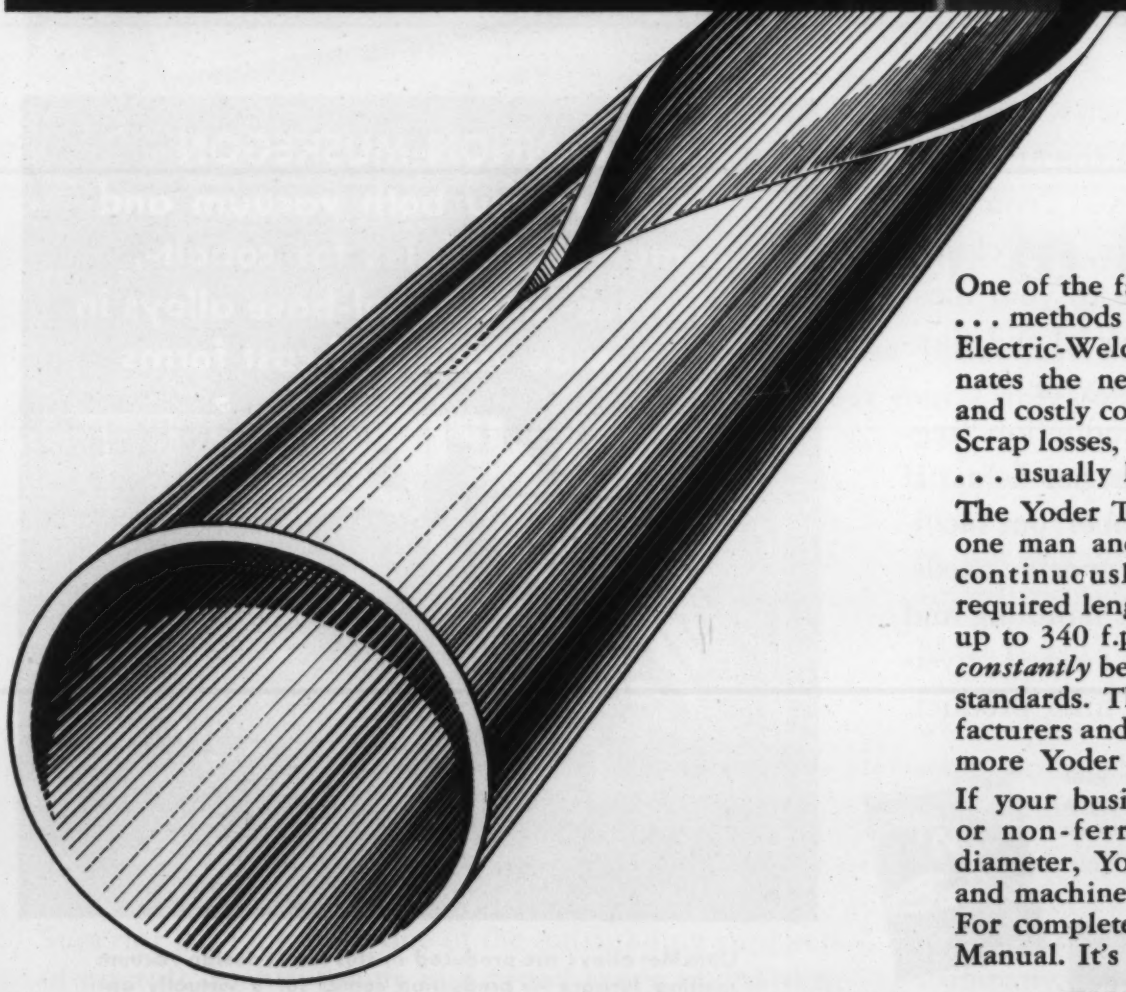
2873 Lincoln Avenue • Muskegon, Michigan, U.S.A.

METALLURGICAL SPECIALISTS

For more information, turn to Reader Service card, circle No. 490

from cold strip to finished tubing
IN SECONDS!
with a YODER
ELECTRIC-WELD TUBE MILL





One of the fastest . . . and one of the least expensive . . . methods of making steel tubing is with a Yoder Electric-Weld Tube Mill. The Yoder method eliminates the need for time-consuming heat treatments and costly conditioning furnaces for most tube needs. Scrap losses, too, are far lower than any other method . . . usually less than 2%.

The Yoder Type-M Mill shown above is operated by one man and a helper. Coiled strip on this mill is continuously cold-roll formed, welded and cut to required lengths in a matter of seconds . . . at speeds up to 340 f.p.m. The quality of the resulting tube is *constantly* better than the requirements of commercial standards. This is one of many reasons why manufacturers and users of tubing the world over are using more Yoder mills than all other makes combined.

If your business requires pipe and tubing, ferrous or non-ferrous, in sizes from ¼-inch to 26-inch diameter, Yoder can supply the engineering service and machines to produce it faster and better for less! For complete details, write for the Yoder Tube Mill Manual. It's yours for the asking.

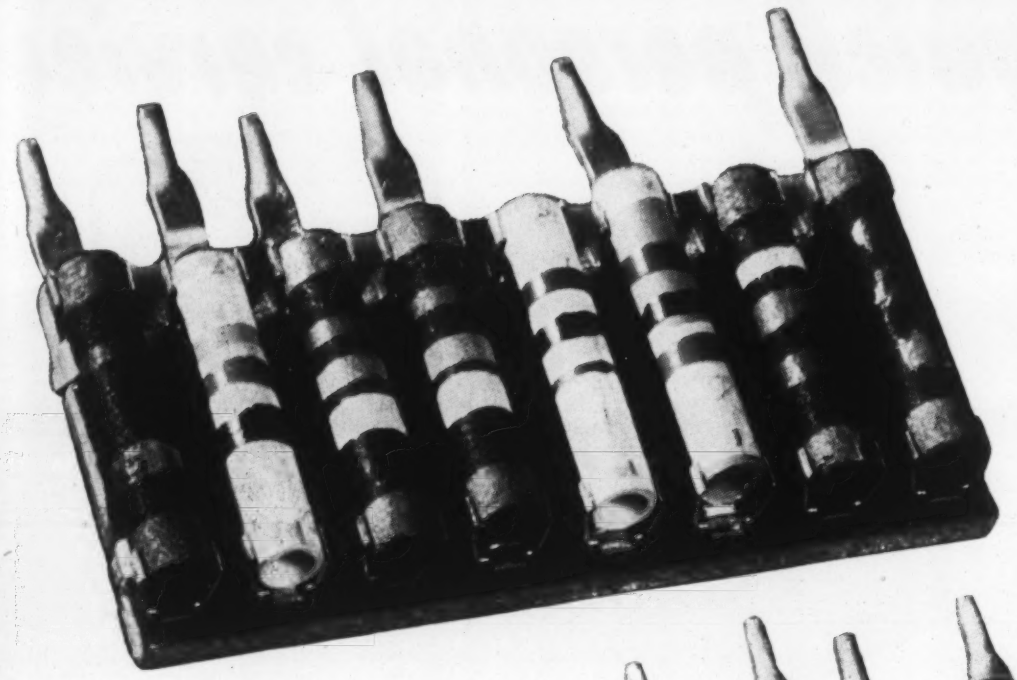
THE YODER COMPANY
5546 Walworth Avenue • Cleveland 2, Ohio

ENGINEERING
YODER
MANUFACTURING

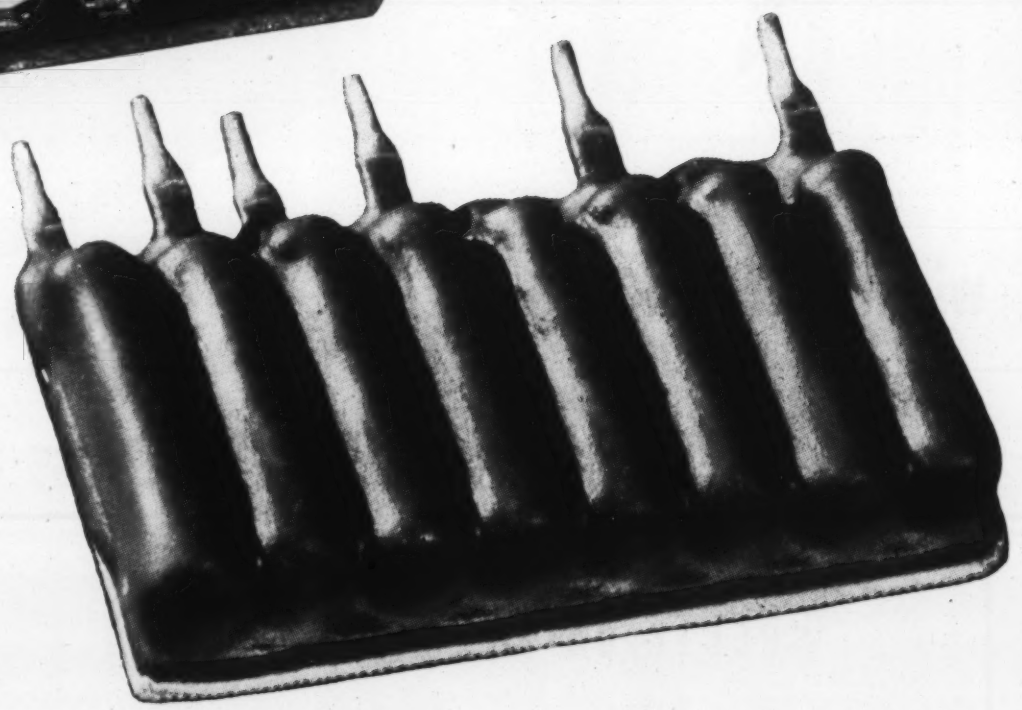
PIPE AND TUBE MILLS (ferrous or non-ferrous)
COLD ROLL FORMING MACHINES
ROTARY SLITTING LINES

For more information, turn to Reader Service card, circle No. 478

wrapping up a problem in electronics



Approx. 2½ times actual size



...Coatings for sub-assemblies suggest **other** jobs for **DUREZ** phenolic **RESINS**

IF YOU ARE FACED with a situation requiring exceptional properties in a bonding, impregnating, or coating agent, consider what Erie Resistor Corp. accomplished when it turned to Durez resins for its Pre-Assembled Components.

DEVELOPED TO EFFECT major cost reductions for electronic equipment manufacturers, these Erie "PAC" circuits combine capacitors and resistors in unitized packages for quick installation in a printed circuit board. Complete flexibility of design is offered in modules combining up to 90 components in one "package."

INSULATING PROPERTIES, mechanical strength, and heat resistance of Durez thermosetting phenolic are key factors in the protective dip-coating applied to "PAC" units. With Durez, Erie meets its own requirements that no migration or peel-back of insulating material occur when a soldering gun is applied. In the dip compound the resin produces a material that is free from running or sagging. The slight porosity of Durez allows Erie's protective wax coating to penetrate to a depth that insures complete insulation, and it cures to a hardness that permits stamping or color coding.

Can the remarkable properties of Durez thermosetting phenolic resins solve a problem for you? Whether thermal, electrical, or mechanical characteristics come first in the application you may have in mind, why not look into Durez now? Feel free to call on our long experience with these materials.

DUREZ®

Phenolic Plastics that Fit the Job

DUREZ PLASTICS DIVISION

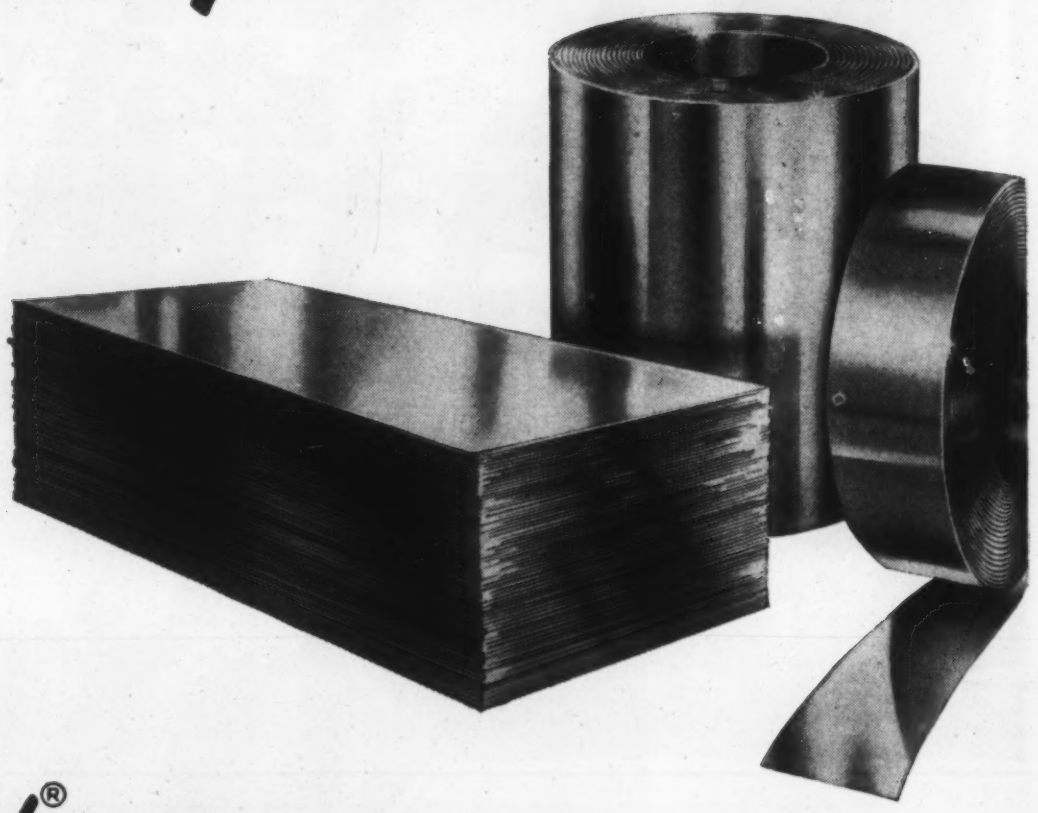
HOOKER ELECTROCHEMICAL COMPANY

1412 WALCK ROAD, NORTH TONAWANDA, N. Y.

HOOKER CHEMICALS PLASTICS

For more information, turn to Reader Service card, circle No. 426

Wherever you are you get *quick personal service*



when you order *MicroRold*® Stainless Steel Sheet & Strip

SPECIFICATIONS

	WIDTH	THICKNESS
SHEETS	up to 36″	.005 to .109
	up to 48″	.010 to .109
STRIP	up to 23 15/16″	.0015 to .090
GRADES:	201, 202, 301, 302, 304, 305, 316, 321, 347, 403, 410, 430 and Micro-Mach (special extra-high-tensile aircraft grade)	

Any one of the 305 independent steel warehouse distributors stocking MicroRold Stainless Steel is ready to serve as your *personal* stainless procurement representative. Located strategically in the U. S. A., Canada and Europe, your MicroRold distributor carries a variety of grades, widths, thicknesses and finishes and is fully qualified to assist you in the selection and fabrication of the most suitable stainless grade for your particular requirements.

Your MicroRold stainless steel distributor assures you of the fastest possible deliveries with an absolute minimum of red tape in order processing. If he is unable to fulfill your needs from stock he has available direct and immediate service from our mill. In cases of emergency, it is possible for us to roll and ship MicroRold Stainless Steel the same day the order is received.

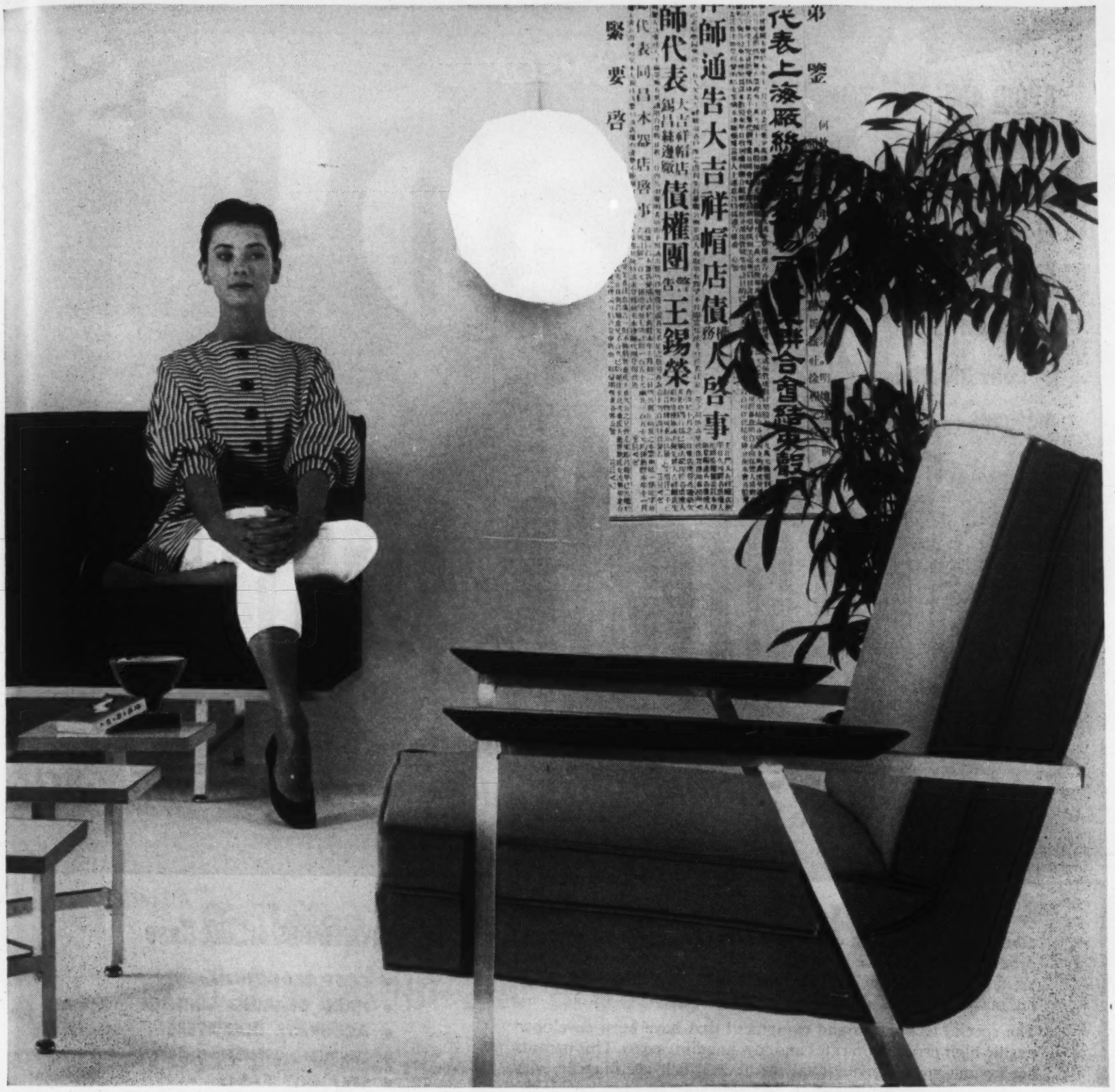
You can rely on MicroRold service as a dependable source of supply, either mill or distributor delivery.

Write, wire or phone today for the name of your nearest MicroRold Stainless Steel Distributor.

WASHINGTON STEEL CORPORATION

12-F WOODLAND AVENUE WASHINGTON, PENNSYLVANIA

For more information, turn to Reader Service card, circle No. 380



Variety—you can choose from a wide range of finishes for magnesium

Smart, modern furniture is just one example of how finishes for magnesium are widening design horizons. Whether for appearance, protection, or a combination of both, the right finish is available. Magnesium can be painted, chemically treated, electroplated, and coated with plastic or rubber.

To meet the rigorous standards set by the aircraft industry, there are air dried and baked paint finishes with excellent adhesion, maximum imperviousness and good wear resistance. Various types of chemical pickling provide the right paint base. Anodizing provides exceptional corrosion, heat and abrasion resistance. In addition, any metal which can be applied by electroplating may be deposited on magnesium.

What about your products? If you're not making use of magnesium lightness, strength and durability—and the variety of finishes for magnesium—there's no better time to start than right now. Contact your nearest Dow sales office or write to us for more information. THE DOW CHEMICAL COMPANY, Midland, Michigan, Department MA 1405K.

YOU CAN DEPEND ON DOW

For more information, turn to Reader Service card, circle No. 371

THOMSON

60 Case hardened and ground

AVOID the HIGH COST and difficulty of fabricating long, hard & straight parts by conventional methods . . .

SHAFTS, ROLLS, GUIDE RODS and other long-round parts

60 Case is the result of over ten years of experimental work and production experience with hardened and ground shafts which are a requirement for BALL BUSHINGS, the Linear Ball Bearing manufactured by Thomson Industries, Inc.

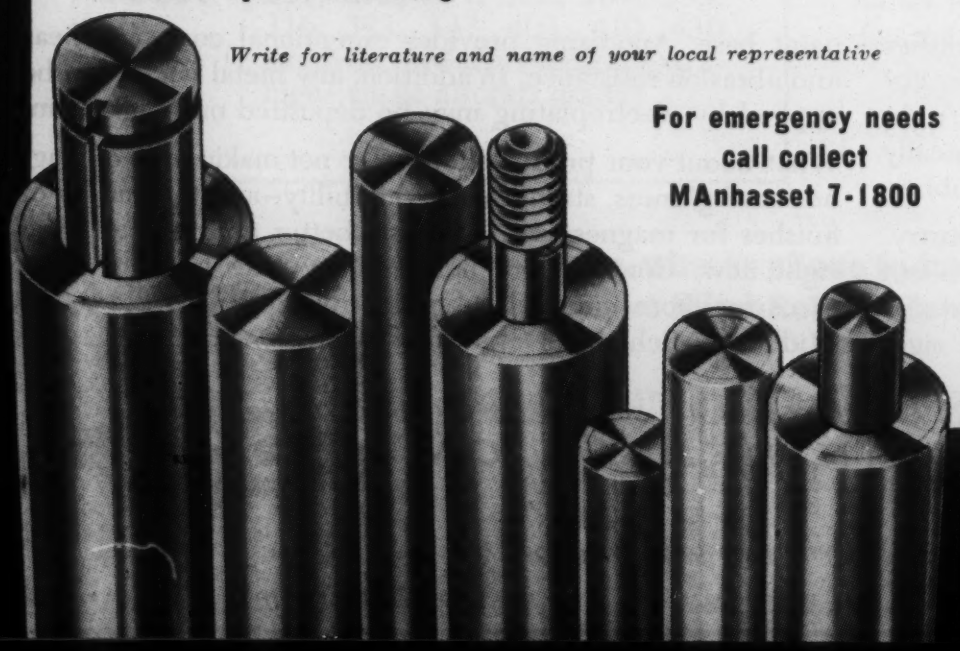
The special techniques and equipment that have been developed enable high production rates and low handling costs. This permits big savings over conventional methods which are plagued with erratic warpage, straightening and resultant grinding problems. Finished *60 Case* parts frequently cost less than the scrap losses that result from conventional methods.

60 Case material has a surface hardness close to 60 on the Rockwell C scale which is essential to resist wear.

Long lengths of material ranging in diameter from ¼" to 4" are stocked to enable prompt shipment of *60 Case* parts, with or without special machining.

Write for literature and name of your local representative

For emergency needs call collect MAnhasset 7-1800



ADVANTAGES of *60 Case*

- COST REDUCTION
- HARD BEARING SURFACE
- ACCURATE DIAMETERS
- GROUND FINISH
- STRAIGHT PARTS
- DELIVERY FROM STOCK
- ADDED STRENGTH
- UNIFORM HIGH QUALITY

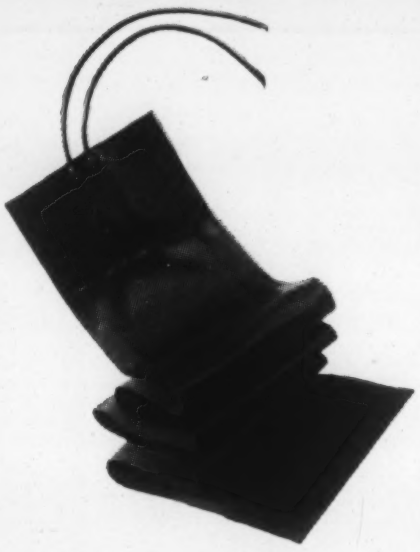
TYPICAL *60 Case* PARTS

GUIDE RODS, SHAFTING, ROLLS, TRAVERSE RAILS, PISTON RODS, ARBORS, LEADER PINS, TIE RODS, KING PINS, AXLES, CONTROL RODS, GUIDE POSTS, MANDRELS, BEARING ROLLERS, SPINDLES

THOMSON INDUSTRIES, Inc.

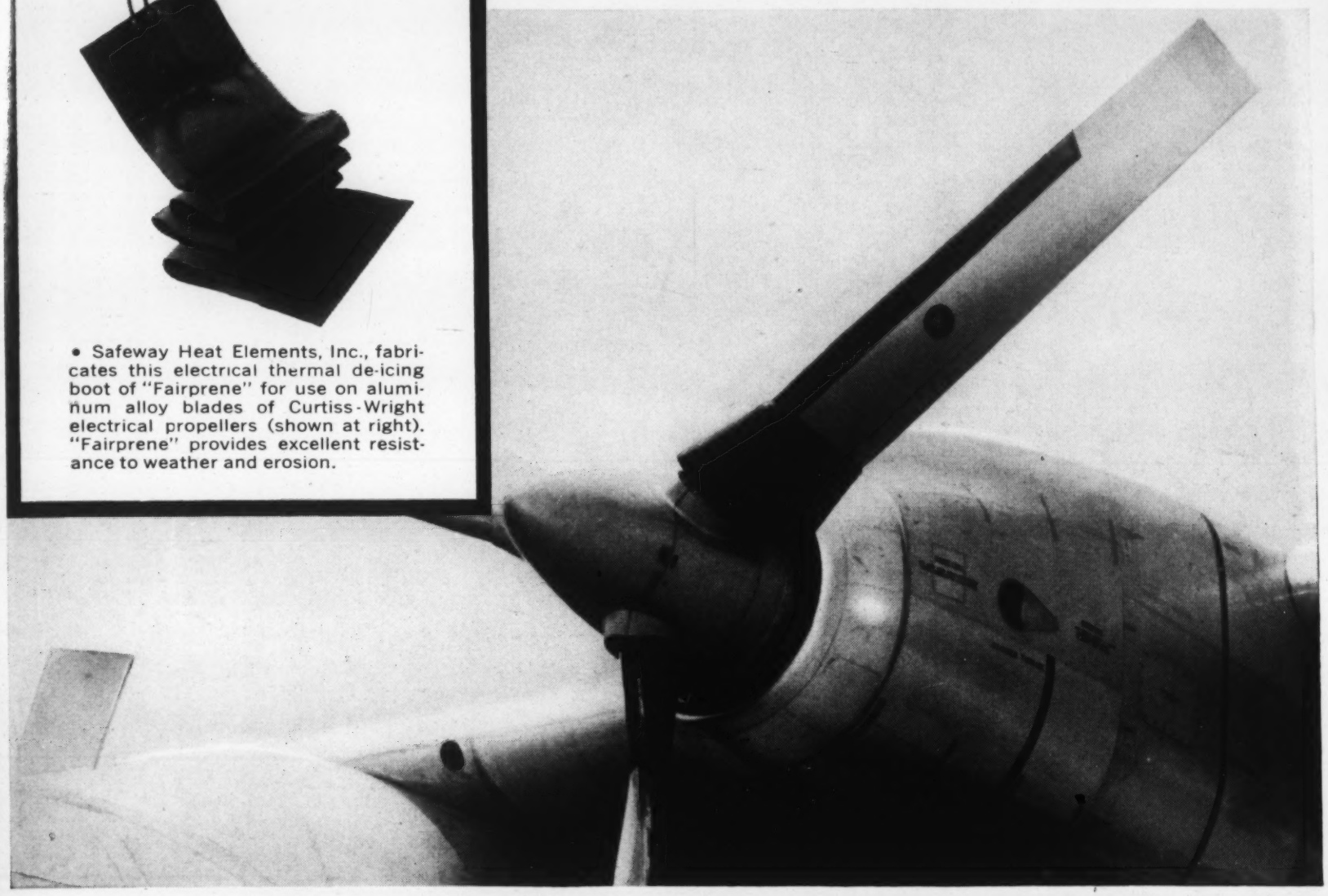
Dept. C7, Manhasset, New York

For more information, circle No. 449



• Safeway Heat Elements, Inc., fabricates this electrical thermal de-icing boot of "Fairprene" for use on aluminum alloy blades of Curtiss-Wright electrical propellers (shown at right). "Fairprene" provides excellent resistance to weather and erosion.

New performance for versatile "Fairprene"
elastomer sheet stock



De-icing boots of Du Pont FAIRPRENE® resist weather and erosion on turbo-props

DU PONT INDUSTRIAL COATED FABRICS

COATING MEDIUMS

Neoprene • Buna-N • Silicone • Polyacrylate
Chlorosulfonated Polyethylene • Tetrafluoroethylene
Butyl • Acrylic • Polyamide
Polyethylene • Polysulfide

SUBSTRATES

Fabrics	Felts or Non-Woven
Cotton . Nylon . "Dacron"*	"Teflon" Felts
Asbestos . Glass	Wool Felts
Rayon . "Teflon"**	

Also elastomer sheet stocks without fabric inserts and cements

**"Dacron" is Du Pont's registered trademark for its polyester fiber*
***"Teflon" is Du Pont's trademark for its tetrafluoroethylene fiber*

DU PONT
REG. U. S. PAT. OFF.

BETTER THINGS FOR BETTER LIVING . . . *THROUGH CHEMISTRY*

De-icing boots of Du Pont "Fairprene"† sheet stock effectively resist abrasive effects of moisture on rotating Curtiss-Wright turbo-props. To develop this material, Du Pont experts worked closely with Safeway Heat Elements, Inc. This same expert assistance is available to help you improve performance or cut costs with an application of Du Pont coated fabrics in your product.

You may need a material to withstand gas, oil or chemicals . . . or to take temperatures to 500°F. Or perhaps your design calls for superior insulation or anti-stick properties. For these and other important qualities there's undoubtedly a Du Pont coated fabric exactly right for the job. For complete information fill out and mail coupon below.

†*"Fairprene" is Du Pont's registered trademark for its coated fabrics, sheet stocks and cements.*

E. I. du Pont de Nemours & Co. (Inc.), Dept. MD-712,
Fabrics Division, Wilmington 98, Delaware
Please send me further information about coated fabrics.
I am interested in using a coated fabric for_____

Name_____ Title_____

Firm_____

Address_____

City_____ State_____

For more information, turn to Reader Service card, circle No. 527

Flag-raising day at another great new Olin Aluminum plant

Cradled in the heart of the Ohio River Valley, this expansive industrial giant is about to spring to life.

Ultra-modern from the ground up, this huge new Olin Aluminum Sheet Mill within a few short months will add its production to the vigorous mainstream of quality Aluminum flowing to the nation from four Olin Aluminum plants.

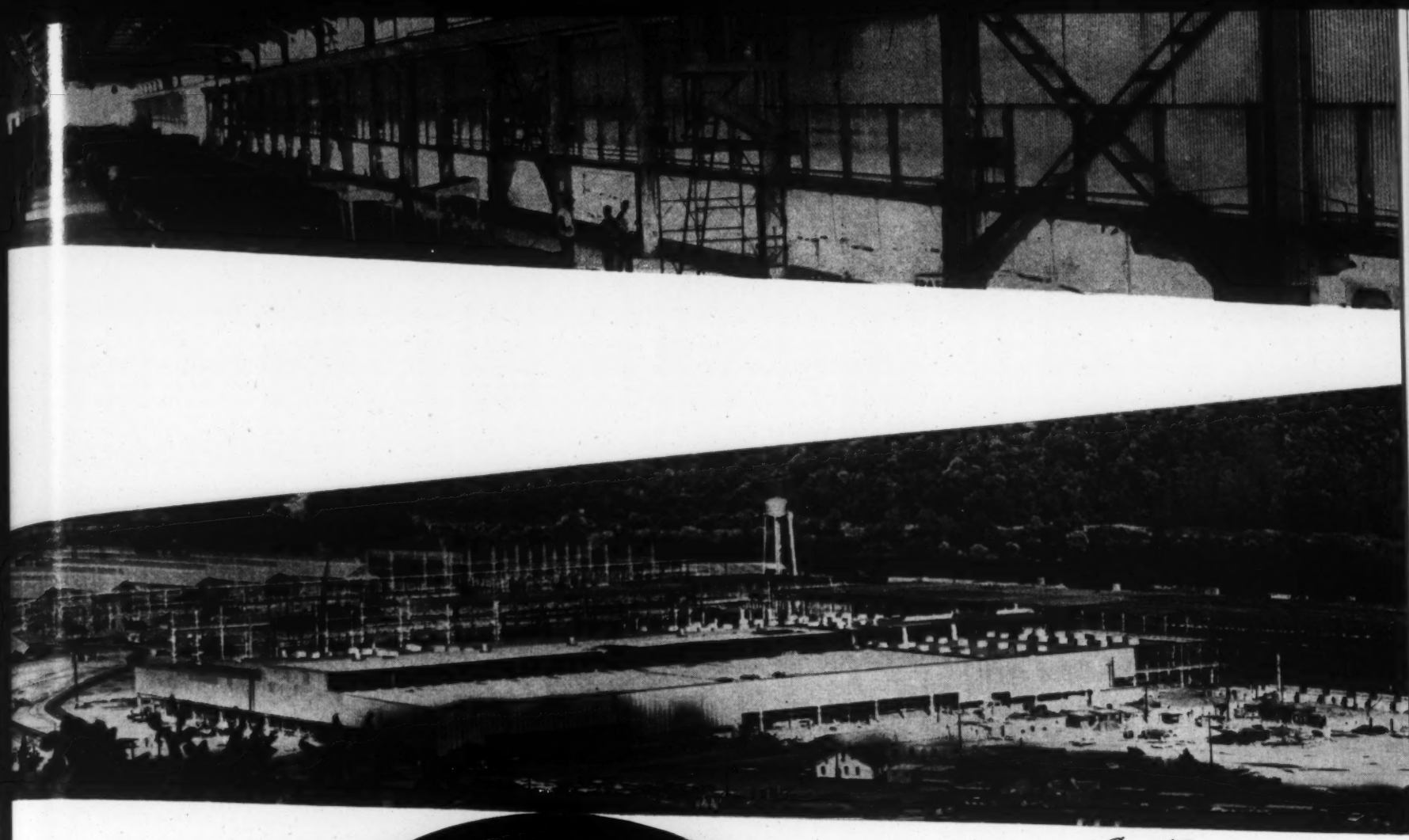
Flag-raising day at this giant new mill will mark an important new chapter in the exciting 22-month growth of Olin Aluminum. New ore ships, rolling mills, extrusion plants and wire and cable mills are already in operation or under construction. With these modern, fully-integrated facilities, Olin Aluminum is right now on the way to an initial annual volume of 340 million pounds of quality Aluminum. And that is only the beginning.

This new Aluminum will be custom-tailored to your specifications. And the unique standards of quality and service by which it will be produced and delivered to you will help you simplify your manufacturing procedures and achieve maximum efficient production from each pound you use.

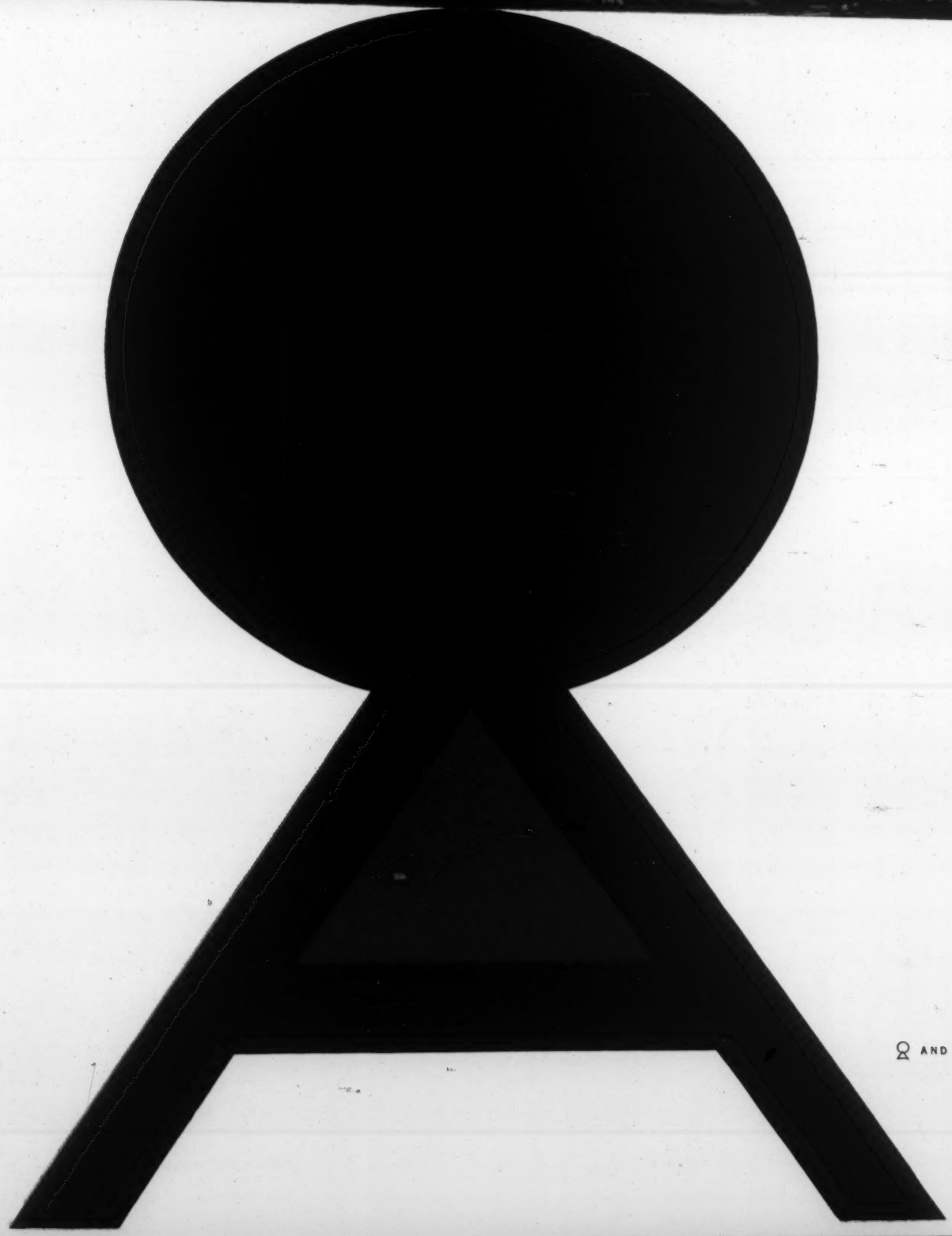
If this is the kind of quality and service you have long been looking for, write now for product availabilities to our new permanent sales headquarters: Aluminum Division—Sales, Olin Mathieson Chemical Corporation, 400 Park Avenue, New York 22, New York.

OLIN ALUMINUM

Symbol of new Standards of Quality and Service in the Aluminum



Giusto



AND "OLIN ALUMINUM" ARE TRADEMARKS

Need Tubing? Then . . .

LOOK NO FURTHER FOR QUALITY

Because *BISHOP* small diameter tubing is not excelled in accuracy of I.D. and O.D. . . . in dimensional precision . . . in tolerances . . . in finish.

Whether it be for a precision part in an instrument . . . a heat exchanger in today's high speed aircraft . . . a thermocouple . . . an electronic or atomic application.

Wherever tubing is needed to meet corrosion, heat, shock, stress, psi pressure resistance and vibration . . . for highest quality and performance *specify* BISHOP tubing, at comparable prices.

SEAMLESS AND WELDED AND DRAWN STAINLESS STEEL TUBING

Mechanical, Capillary, Hypodermic and Aircraft Grade

(.008" to 1.000" O.D.—.003" to .083" Wall)

NICKEL AND ALLOY TUBING

(up to .625" O.D.)

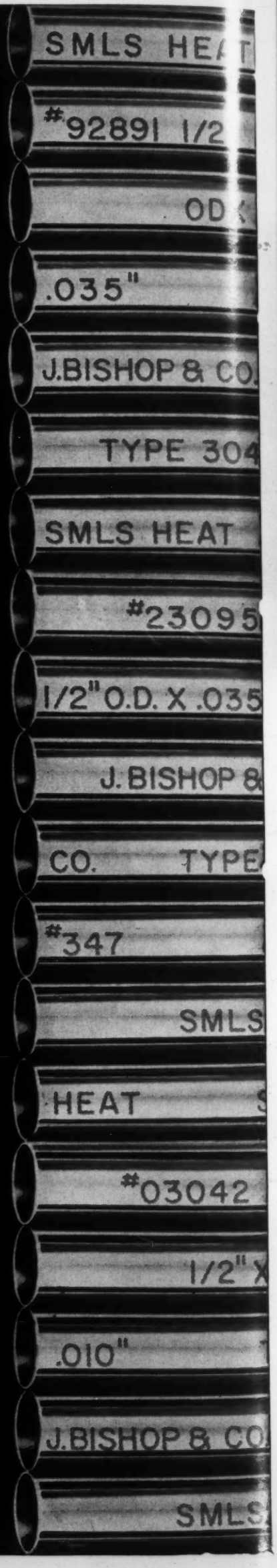
TUBULAR FABRICATED PARTS

Flanged, Flared, Milled, Slotted, Swaged and Threaded

GLASS-TO-METAL SEALING ALLOYS

CLAD METALS & COMPOSITE WIRES

Catalogs on Request. For Prompt Service, Fast Deliveries Call Malvern, Pa. 3100



STAINLESS STEEL PRODUCTS DIVISION

J. BISHOP & CO. Platinum Works

Malvern, Pennsylvania

For more information, turn to Reader Service card, circle No. 378

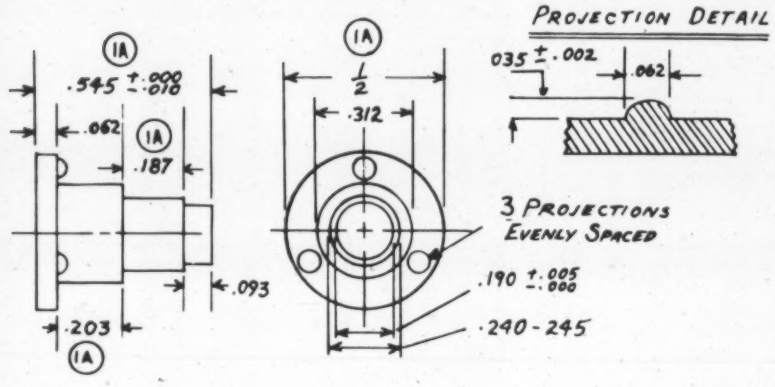
For more information, circle No. 546

from 5 Expensive Operations to—

2 blows!

KEYSTONE XL WIRE STUDY

3.5 TIMES ACTUAL SIZE



Shaft for nylon rollers used in cabinet drawers. The blank formerly was made in 4 cuts on a screw machine — then the 3 tiny projections which anchor the nylon rollers were spot welded. Now Milford cold heads the part from Keystone "XL" Wire with one secondary operation to turn the small tenon. The two major shoulder diameters, head and projection, are produced in just two blows.

MILFORD RIVET

The MILFORD RIVET & MACHINE CO. finds Keystone Wire saves 70% in Costs . . . 85% in Time

Here is a typical example of how Milford uses Keystone "XL" Wire in meeting difficult cold upsetting requirements. Milford estimates that savings of 70% in cost and 85% in time have been effected by cold heading the part illustrated above as compared with the four operations it formerly took on a screw machine plus spot welding. Milford puts Keystone "XL" Wire to work at its five plants — Elyria, Ohio; Milford, Conn.; Hatboro, Pa.; Aurora, Ill.; and Norwalk, Calif. Milford recognizes *flowability* of Keystone "XL" Wire as the key to profitable runs of quality fasteners.

Manufacturers come to Milford with specific fastener requirements — then skilled Milford engineers design quality cold-formed parts. Here's where *teamwork* pays off. Milford and Keystone representatives find the most practical solution to metallurgical problems. This results in high quality — yet economical parts — fabricated perfectly for the job they were designed to do.

Close counsel and analysis of your wire problems are services you receive from your Keystone representative. Call him today!

Keystone Steel & Wire Company, Peoria 7, Illinois

KEYSTONE
WIRE FOR INDUSTRY

Keystone Steel & Wire Company
Peoria 7, Illinois

Brand New . . . COLD HEADING FACTS FOLDER . . . send coupon today! New folder discusses uses, applications, methods, technical facts, wire requirements.

Name_____ Title_____

Company_____

Street_____

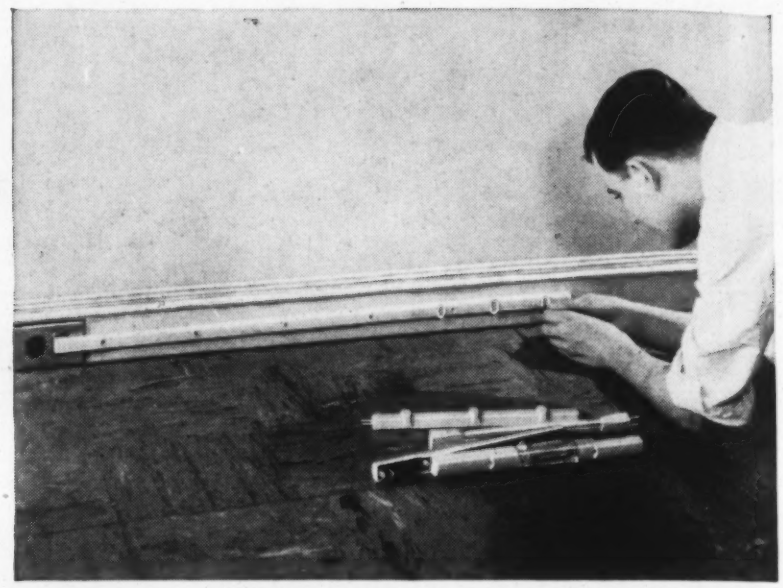
City_____ State_____

CYANAMID

PLASTICS NEWSFRONT

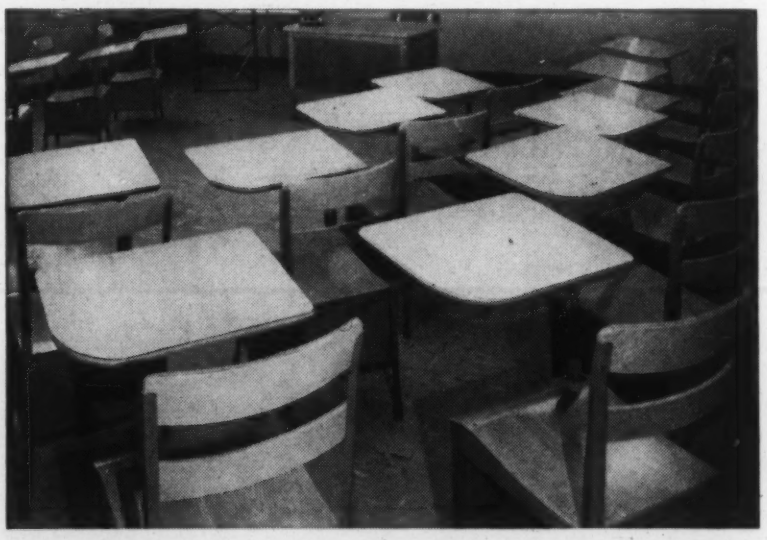
BABY-FEEDING WARE WITHSTANDS FREQUENT BOILING—AND BABY

Clever design and practical purpose are combined in the attractive baby-feeding ware and educational toys molded by North Star Industries of CYMAC® 400 polymethylstyrene molding compound. Thanks to CYMAC, all pieces are boilable—can be sterilized as often as necessary without distortion, cracking or discoloration. CYMAC upgrades products, provides better quality at competitive cost.



NEW LOW-COST ELECTRICAL OUTLET SYSTEM

Made from ivory-colored BEETLE® urea molding compound, these interlocking foot-long units provide low-cost, easily installed electrical outlets wherever they're needed. BEETLE's strength and excellent insulating properties guarantee safe, dependable service. Its hard smooth surface resists scratching and discoloration. Made by Cable Electric Products Inc., Providence, R. I., this new Snapit Inter-Link system is fully approved by Underwriters Laboratories Inc., a sure indication of its quality and safety.



PLASTIC DESK TOPS HERE TO STAY

"Not a single delamination caused by a faulty glue line" is the proud record of Desk Tops Inc., major supplier of school desk tops east of the Mississippi. URAC® 185 urea resin adhesive is used to bond hardwood plywood cores to rich CYMEL® melamine resin plastic surfaces. These resins are exceptionally strong and are fully resistant to moisture, heat and chemicals. Desk Tops Inc. guarantees tops against glue failure...will use no adhesive other than URAC 185.

AMERICAN CYANAMID COMPANY
PLASTICS AND RESINS DIVISION
34M Rockefeller Plaza, New York 20, N. Y.

In Canada: North American Cyanamid Limited, Toronto and Montreal

Offices in: Boston · Charlotte · Chicago · Cincinnati · Cleveland · Dallas · Detroit
Los Angeles · New York · Oakland · Philadelphia · St. Louis · Seattle

CYANAMID Plastics and Resins Division
MATERIALS FOR TOMORROW

For more information, turn to Reader Service card, circle No. 422

THIS IS GLASS

a bulletin of practical new ideas from Corning

Pressures of the jet age

To take pressure readings from a jet engine sealed in a test cell, this man is using what may be the Gargantua of all manometers.

A number of these mammoth manometers (each stands better than *2 times as tall* as the average male) are used by Aro, Inc., operating contractor for the U. S. Air Force, Arnold Engineering Development Center, a collection of men and machines devoted to probing matters related to *supersonic* propulsion.

Trimount Instrument Company of Chicago makes these king-sized instruments, the main component of which is glass tubing.

This tubing is made from a PYREX brand glass. And like all items carrying the PYREX trademark, the tubing comes from Corning.

Here's why, according to the people at Trimount, they "take from" Corning for their tubing needs:

"We have found through years of experience that PYREX brand tubing is the finest for our requirements. Corning draws it to our specifications. For uniformity and extremely close tolerances required in our instruments, as well as strength and rigidity under high pressures, we specify closely held I.D. and O.D. tolerances. Also, the lengths required are important as we prefer not to use welded glass tubing . . ."

Such praise seems ample evidence that turning to Corning for glass components is sound practice from both an engineering and profit standpoint.

Thusly, an invitation to consider and investigate at your convenience. Outline your needs and we'll put our people versed in your field to work.

Or, peruse at leisure a recently issued book called "This Is Glass." It's filled with facts and pictures about glass at work in products and processes. Free.

Profitable pursuits from pipe dreams

Pipe dreams being of an illusory and mostly impractical nature, we offer instead some *dream pipe*.

Having need for more precise terms, those in our office who write orders call this dream stuff PYREX brand glass pipe.

Admittedly, this mundane phrasing tells little about the many talents of such pipe.

For example, it is eminently practical for *unusual* plumbing tasks, being equally at home handling waste acids of a corrosive nature or carrying milk from cow to bottle in modern dairy processing setups.

Immune to corrosive attack from most materials, PYREX brand glass pipe is easily installed, carries waste acids safely and economically.

Longevity is one of many trump cards you'll hold with a handful (figurative) of PYREX pipe. Like? An actuarial-minded chap once estimated that a section of pipe *will last some 203 years on a steady diet of hydrochloric acid.*

Equally valuable is the fact that you can keep constant visual surveillance over what's being piped. If plug-ups occur, you can see where they are and get at them easily.

Also yours with any item made from PYREX brand glass No. 7740 is *ruggedness* from the standpoint of thermal shock. With a coefficient of expansion of 32.5 x 10^{-7}, you can safely use this glass for high heat environments and/or where abrupt temperature changes are common.

Physical strength is also built in. Example: In a southern paper mill there's a 400 ft. installation of 3" (O.D.) PYREX pipe handling a *mercury amalgam*. Obviously, knowing men would never trust such an assignment to any material suspect of being *frangible*.

There's a lot more about PYREX glass pipe in Bulletin EA-1. There's a lot more about the PYREX brand and other glasses in Bulletin B-83. Glad to send you either or both.

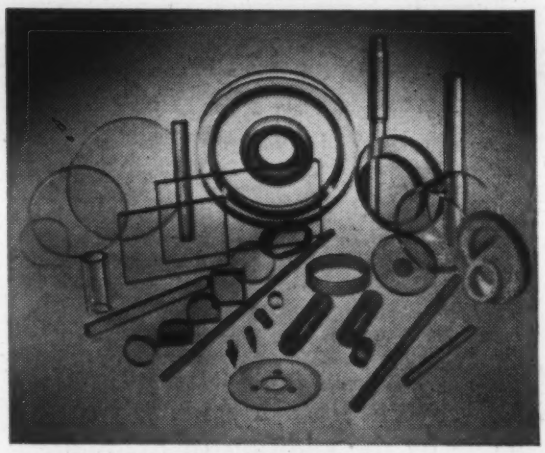
Close finish

During World War II considerable effort and experimentation were devoted to precision finishing for glass.

Since then, little has been said but quite a lot done in this field. For example, Corning makes for one customer the impeller, housings, and bushings for *an almost-all-glass pump*.

Made from PYREX brand glass No. 7740, these glass pump parts are precision ground and finished to terrifically tight tolerances.

Some of the other shapes and forms readily available with precision finishes are shown in this picture.



And this table will give you some idea of the operations and tolerances on tap at Corning.

Operation	Tolerances (inches)
Flat grinding and polishing	±.0005
O.D. grinding	±.0002
Internal grind, Step grooves, Angles and Tapers	±.0005
Circular Holes	±.005
Rectangles, Squares, etc.	±.001

Tubing, cylinders, rod, ground and polished discs and rectangles . . . these and many, many other glass forms await your investigation.

If you have some *tight* problem already at hand, brief us and we'll advise on the practicability of supplying you with a glass product to do the job.

Corning means research in Glass

CORNING GLASS WORKS, 50-12 Crystal Street, Corning, N. Y.

Please send me the following material: "This Is Glass" ☐; EA-1—"PYREX brand Glass Pipe in the Process Industries" ☐; B-83—"Properties of Selected Commercial Glasses" ☐.

Name_____ Title_____

Company_____

Street_____

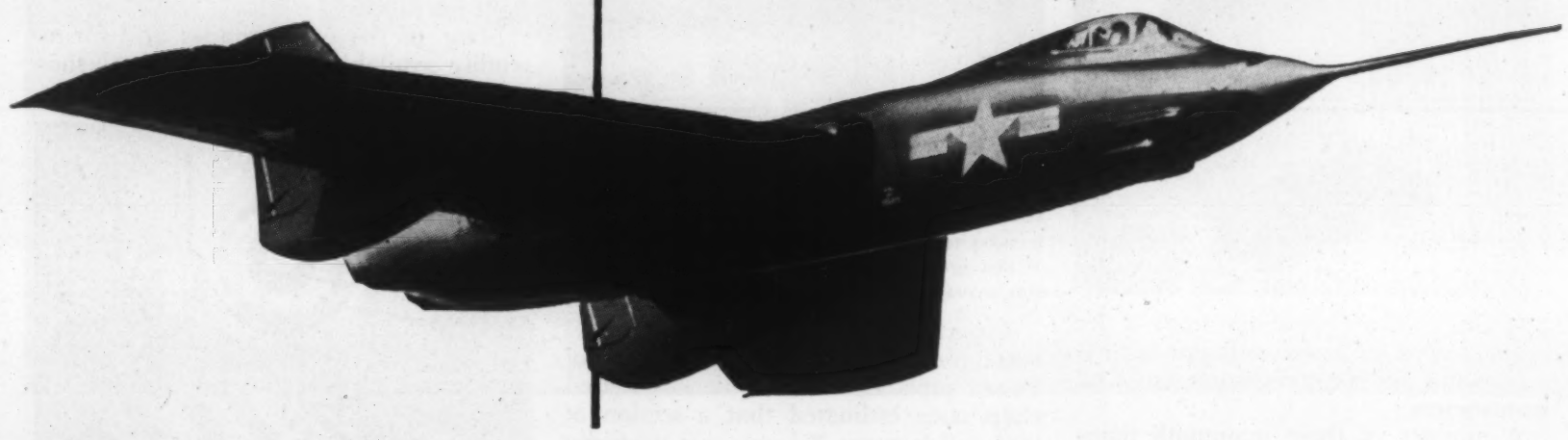
City_____ Zone_____ State_____

For more information, turn to Reader Service card, circle No. 369

For your selection

ALTEMP

HIGH TEMPERATURE SUPER ALLOY STEELS



ALTEMP A-286 . . . an austenitic iron-nickel-chromium alloy made heat-treatable by the addition of titanium. Designed to maintain high strength and corrosion-resistance up to the 1350 F range, and to afford satisfactory scale resistance up to 1800 F.

A-286 was developed in the A-L Research Laboratory in Watervliet, N.Y., in the 1949-51 period. Among the high-strength, heat-resisting alloys, it has exceptionally low strategic alloy content, improved hot-working and machining qualities, and good center ductility in large sections. Currently used in jet engines and superchargers for such applications as turbine wheels and blades, frames, casings, afterburner parts, bolting, etc.

This alloy is readily produced in large quantities without the need of special steel-making equipment. It is available in the form of billets, bars, forgings, sheet, strip, tubing and hot-extruded shapes.

ALTEMP S-816 . . . a chromium-nickel-cobalt base alloy, strengthened by additions of molybdenum and tungsten, and with a columbium-carbon ratio of ten to one to insure its structural stability. Designed for high strength and corrosion-resistance service in the 1200-1500 F range, and at higher temperatures under lower stress conditions. Developed in the A-L Research Laboratory at Watervliet, N.Y. in the years of 1940-43, and engine-tested and proved for periods of over 30,000 hours.

S-816 is used currently for turbine blades in two of the production jet engines, also in a number of experimental aircraft and commercial gas turbines. Except for seamless drawn tubing, it is available in practically all forms and shapes in which stainless steels are processed, including hot extrusions.

ALTEMP S-590 was designed for service in the range of 1100-1400 F temperatures where high strength and corrosion resistance are required, and where cost is also a factor. Unlike S-816, which is practically a non-ferrous alloy, S-590 has a chromium-nickel-cobalt-iron base. However, it employs the same molybdenum and tungsten additives, and the same columbium-carbon ratio.

S-590 was developed at the Watervliet Laboratory and field-proved during the same years as S-816. It is available in the same shapes and forms, and is currently being used for turbine blades and wheels in experimental commercial gas turbines.

OTHER GRADES . . . among the many other Super Alloys made by Allegheny Ludlum are V-36, M-252, 19-9 DL, 19-9 DX and Waspaloy.

Do you have a high temperature problem? The services and experience of our Research Laboratories and Technical Staff are completely at your command. *Allegheny Ludlum Steel Corporation, Oliver Building, Pittsburgh 22, Pa.*

WSW 8310 B

WRITE FOR INFORMATION

Certified laboratory data on the properties of Allegheny Ludlum high temperature Super Alloy Steels are yours on request.

ADDRESS DEPT. MM-96

PIONEERING on the Horizons of Steel

Allegheny Ludlum

Stocks of AL Stainless Steels carried by all Ryerson warehouses

AL LEADING PRODUCER HIGH-ALLOY STEELS

For more information, turn to Reader Service card, circle No. 504

Here's Fine Line Etching ...375 Times Enlarged!

Actual Size

This is what Taylor means by *better* printed circuits . . . the unretouched photograph above is an enlargement of the miniature etched test coil shown at right. Here is a dramatic illustration of exactly what Taylor means by saying rolled copper-clad laminates give you *better* printed circuits. Enlarged 375 times, this photograph shows how the .002" wide conductors are parallel and free of pits, pinholes and lead inclusions.

Here's proof of why you'll be satisfied with your printed circuits . . . if they're made with Taylor copper-clad laminates. You're assured of a uniform material, offering consistently satisfactory etching . . . better production rates.

For more detailed information on Taylor copper-clad laminates . . . for a discussion on how these laminates can help you produce *better* printed circuits . . . contact your nearest Taylor sales office.

TAYLOR
Laminated Plastics
Vulcanized Fibre

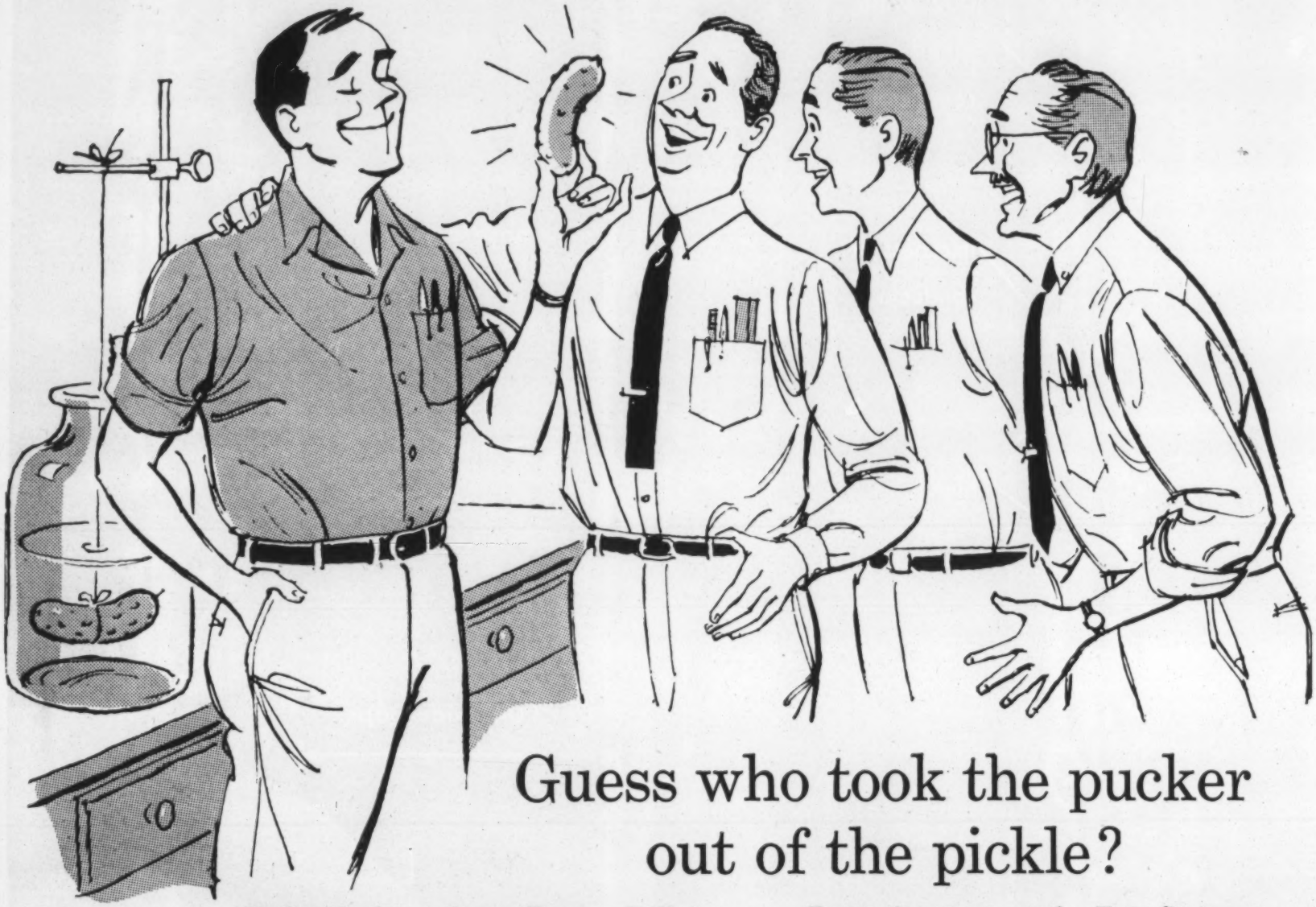
TAYLOR FIBRE CO., PLANTS IN NORRISTOWN, PA. AND LA VERNE, CALIFORNIA

INTEGRATED MANUFACTURER & FABRICATOR OF
Phenolic—Melamine—Silicone—Epoxy—Copper-Clad and
Combination Laminates • Vulcanized Fibre

FIRST AND LARGEST PRODUCER OF ROLLED COPPER-CLAD LAMINATES FOR BETTER PRINTED CIRCUITS

For more information, turn to Reader Service card, circle No. 498

Any similarity to a real-life company is purely intentional



Guess who took the pucker out of the pickle?

If they had to rely on Barney Billet to keep the wolf from their doors, the pickle packers would soon pound a path to the poorhouse. For the truth is Barney doesn't like pickles. To him, a cucumber is just something to stay as cool as.

So what does Barney do for a living? Why he's a major-domo of a pickling tank at O-So-Strong Steel Company!

He does a good job — pushes plenty of tonnage through the tank. Barney rates ace-high with the top ingots (you wouldn't expect *brass* in a steel mill, would you?).

They've given him the finest equipment to work with. It's *got* to be good—the pickling operation uses a 12% sulphuric-acid solution at 200°F. And that can make a meal of most metals. But not of Ampco Metal! It's a series of special, super-tough copper-base alloys specially engineered to resist wear and corrosion.

That's why O-So-Strong fabricated the strip rollers and side plates from Ampco Metal. They're practically immersed in the pickling-tank solution—but meet the acid test without puckering.

Down the street, at the Even-Stronger Steel Company, replacement costs have dipped, also, since they've used Ampco Metal in pickling hooks, crates, baskets, yokes, and chains.

Ampco Metal has shown its mettle in other ways; for example, in rolling-mill applications where resistance to wear and shock loads is important — in screw-down nuts, screw-down worm wheels, slippers, breaker blocks, and other critical parts.

Though pickling may not have *you* in a pickle, chances are this story still applies to you. For nothing solves most wear, corrosion, erosion, abrasion, or cavitation problems like Ampco Metal. You can get it in any form — sand-cast, centrifugally-cast, shell-molded, precision-cast, forged, fabricated, extruded, sheet, or plate.

Your Ampco field engineer is the one to give you all the facts. Call him in. And write for Bulletin 33. *Ampco Metal, Inc., Dept. MDE-12, Milwaukee 46, Wisconsin.*

(West Coast Plant: Burbank, California)

AMPCO® METAL

The metal without an equal

G-8

For more information, turn to Reader Service card, circle No. 363

DON'T BE A SQUARE ABOUT CIRCULAR PROBLEMS

Reduce material waste and excess machining with Cleve-Weld circular welded components!

Because Cleve-Weld parts are designed close to finish dimensions, you can plan on cost reduction in three important areas:

1. Cut machining waste up to 30%.
2. Eliminate unnecessary machining.
3. Speed up your over-all production.

Where titanium and other "wonder metals" are specified, Cleve-Weld circular components practically pay for themselves in material and machining time savings.

The Cleve-Weld Process reflects 45 years of specialization in welding facilities and circular component production methods. This specialization can *make the difference* in your product. Find out how by calling, writing or sending drawings to:

Circular Welded Products Department,
American Machine & Foundry Company
Cleveland Welding Division,
West 117th St. and Berea Road, Cleveland 11, Ohio

Another AMF Product
CLEVE-WELD PROCESS
RIMS · RINGS · WELDMENTS

CLEVELAND WELDING DIVISION
AMERICAN MACHINE & FOUNDRY COMPANY
Cleveland 11, Ohio

ACCELERATE . . . Mail this coupon Now!

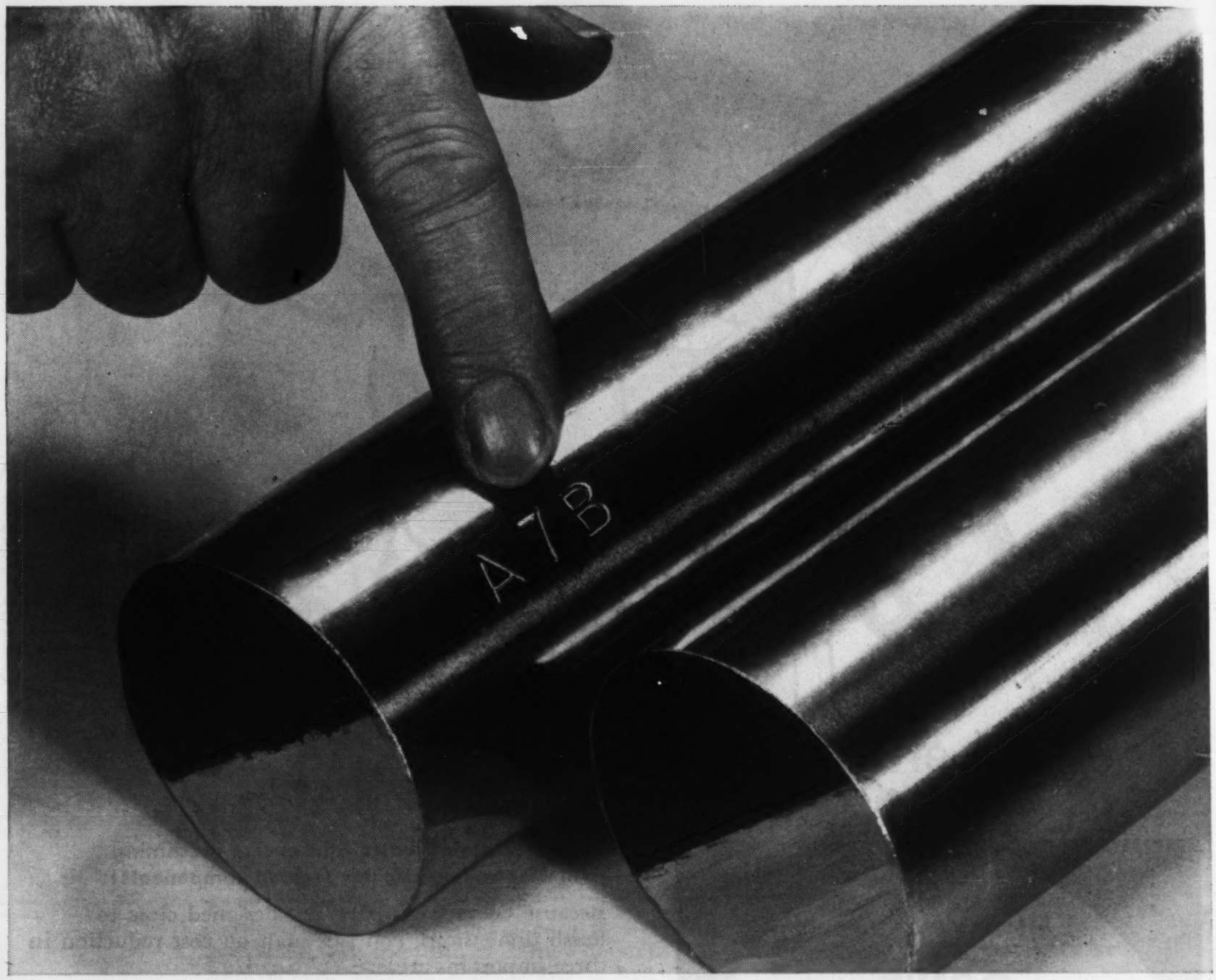
. . . for a brochure on Cleve-Weld's metallurgical, design and production facilities. Find out more about how the Cleve-Weld Process cuts component costs while improving their performance. MM-712.

NAME_____

TITLE_____

ATTACH TO YOUR COMPANY LETTERHEAD AND MAIL

For more information, turn to Reader Service card, circle No. 408



With ONE you know, the other you don't

Two alloy steel bars of the same type can differ markedly in hardenability—if they come from different furnace heats. But with Ryerson 8-step quality control, there's no need to guess. Every Ryerson alloy bar is positively identified by heat number. You get a "heat history" report with every order.

Here's what the Ryerson report tells you:

1. **Heat analysis.** Not just the chemical range for the type of alloy, but the specific analysis of the heat from which your steel was rolled.
2. **Tested Hardenability.** Not just the average hardenability for the alloy, but the actual Ryerson-tested hardenability for the particular heat . . . as quenched and at three draw temperatures.

You can always be *sure* with alloys from Ryerson. On your next order, get the protection offered by the Ryerson Certified Alloy Steel plan. It costs no more. Call your nearby Ryerson plant.

RYERSON CERTIFIED QUALITY

RYERSON STEEL

Principal products: Carbon, alloy and stainless steel—bars, structurals, plates, sheets, tubing—aluminum, industrial plastics, metalworking machinery, etc.

JOSEPH T. RYERSON & SON, INC. PLANTS AT: NEW YORK • BOSTON • WALLINGFORD, CONN. • PHILADELPHIA • CHARLOTTE • CINCINNATI • CLEVELAND
DETROIT • PITTSBURGH • BUFFALO • INDIANAPOLIS • CHICAGO • MILWAUKEE • ST. LOUIS • LOS ANGELES • SAN FRANCISCO • SPOKANE • SEATTLE

For more information, turn to Reader Service card, circle No. 377

DOW CORNING CORPORATION

Silicone News

FOR DESIGN ENGINEERS No. 45

New "Shape-it-yourself" Silastic Vulcanizes at Room Temperature

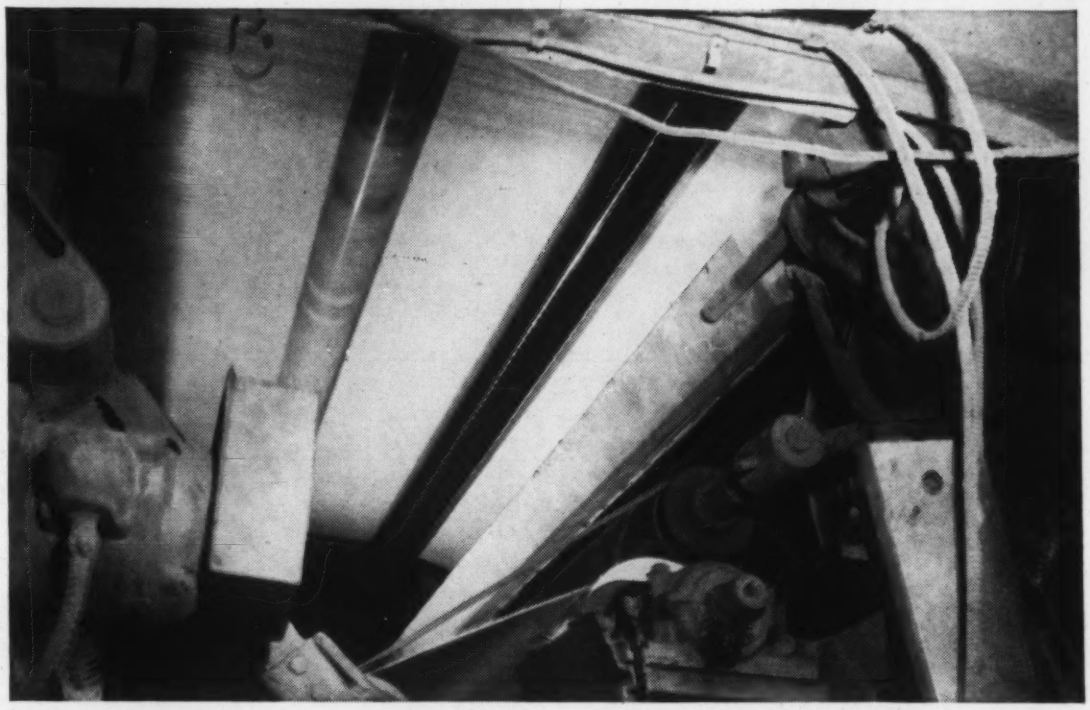
A new, room temperature vulcanizing silicone rubber with excellent handling characteristics and durability is now available from Dow Corning.

The new rubber, Silastic* RTV 501, stays rubbery from —70 to 500 F and has exceptional resistance to moisture and weather. These and the other properties shown below make Silastic RTV 501 ideal for encapsulating electric and electronic assemblies and for general potting, sealing and calking applications.

Easy to process, the new silicone rubber has a long shelf life and mixes easily with the recommended catalyst. The two ingredients can be blended either manually or mechanically as long as three hours before being used. Both the fluid polymer and catalyst have a viscosity of approximately 60,000 centistokes. Silastic RTV 501 cures at room temperatures within 24 hours and attains maximum physical properties in only 2 to 3 days. *No. 456*

Typical Properties of Silastic RTV 501	
Serviceable temperature range	—70 to 500 F
Electric strength, volts/mil	300 to 500
Dielectric constant, 10^2 cycles per second	2.6
Dissipation factor, 10^2 cycles per second	0.01
Water absorption after 70 hours at 212 F, percent	Nil

*T. M. REG. U. S. PAT. OFF.



SILICONE ADHESIVES AID DEVELOPMENT OF PRESSURE-SENSITIVE TEFLON TAPES

With the aid of Dow Corning 274 Adhesive, the first pressure-sensitive adhesive ever developed that will stick to Teflon, Minnesota Mining has introduced a new Teflon-coated "Scotch" brand tape with a wide field of potential applications.

Applied to main carrying rollers on machines making heavily sized papers, for example, this new 3M tape promises to eliminate one of the "stickiest" problems in the paper industry. Sizing accumulates on these rolls so rapidly that repeated shutdowns are necessary to clean them before the paper is ruined, or before the build-up hardens and must be chiseled off.

Now, however, by simply half-lap wrapping the steel rollers with the new Teflon-silicone adhesive tape, the sizing is repelled and maintenance costs reduced.

The effectiveness of this wrapping, which adds only 3 to 6 mils thickness, is demonstrated in the photo above. Note how the lead carrying roller on the right, wrapped with tape a year ago, is still as clean as a whistle. In contrast, the steel-surface roller is almost completely covered with sizing even though it occupies a less vulnerable position in the line-up.

Coating the steel rollers directly with Teflon would produce a similar effect but at a prohibitive cost. The 3M tape is so economical that in some cases it has paid for itself in a single day's run!

Facts about Dow Corning silicone adhesives: Because of their semi-inorganic nature, silicone adhesives have many unusual properties. Pressure-sensitive tapes based on them stick to almost anything including wet surfaces. Silicone adhesives possess good strength, are superb electrical

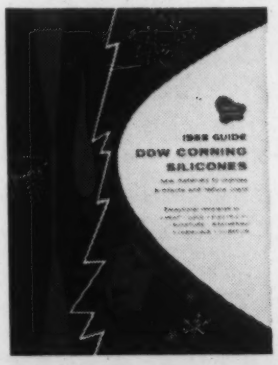
(*Cont. Pg. 2*)

ALL-NEW REFERENCE GUIDE TO SILICONE PRODUCTS NOW AVAILABLE

Most complete reference guide to silicones ever produced, describes Dow Corning silicone products now available in commercial quantities: fluids, lubricants, resins, adhesives, varnishes, dielectrics, rubber, water repellents, textile finishes, leather treatments, and other specialized forms.

Its 16 pages are filled with data and illustrations suggesting ways in which you can cut costs, simplify designs, improve performance and add new sales appeal to your products with Dow Corning Silicones.

Cross-indexed for handy reference, this all-new 1958 Guide includes properties and uses for the many new silicone products developed in recent months. A "must" for every design reference file, you can obtain your Free Copy by circling . . . *No. 457*



FOR DATA RELATING TO THESE ARTICLES, CIRCLE REFERENCE NUMBER IN COUPON ON NEXT PAGE

MORE

DOW CORNING CORPORATION

Silicone News

NEW LITERATURE AND TECHNICAL DATA ON SILICONES

Silastic—in mechanical applications—increases life and serviceability of original equipment; reduces maintenance and downtime. A completely new brochure gives properties and cites applications and case histories to help you use this versatile silicone rubber to best advantage in your application. *No. 460*

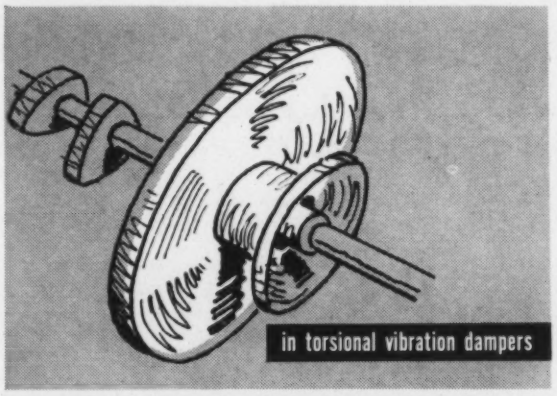
Dow Corning Silicone Lubricants, including oils and greases, are described in a new, illustrated 8-page brochure that gives their properties, lists their applications, and cites factors which contribute to obtaining longer life. *No. 461*

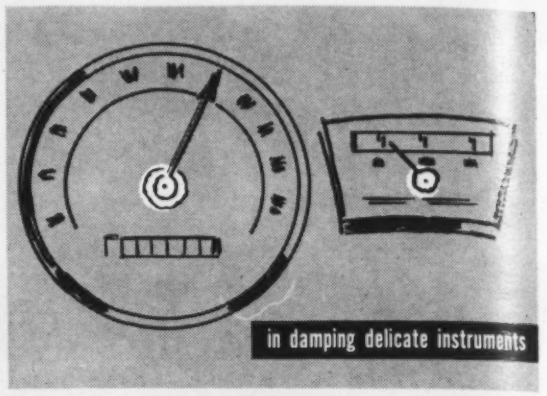
Silicone Materials in Appliance Design, a recent article in ELECTRICAL MANUFACTURING, lists a variety of applications for several different silicones in appliances, describes how silicones have made possible design changes heretofore impractical, and how they extend service life and dependability. *No. 462*

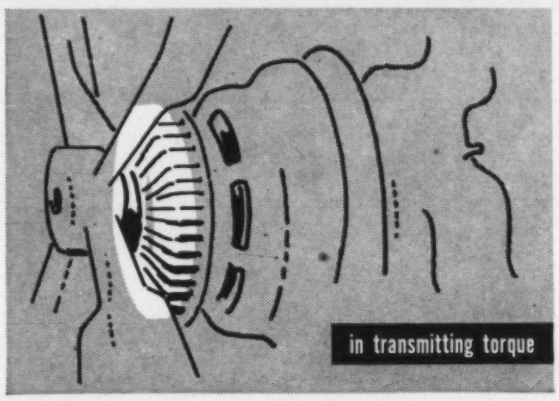
Solventless Silicone Impregnating Resins now commercially available for electrical and electronic equipment, are free-flowing, can be blended, and have good pot life. On curing, these silicone encapsulating resins set to a solid mass having good electrical and physical properties; and retain such properties that a service life of 10 years at 400 F is indicated. *No. 463*

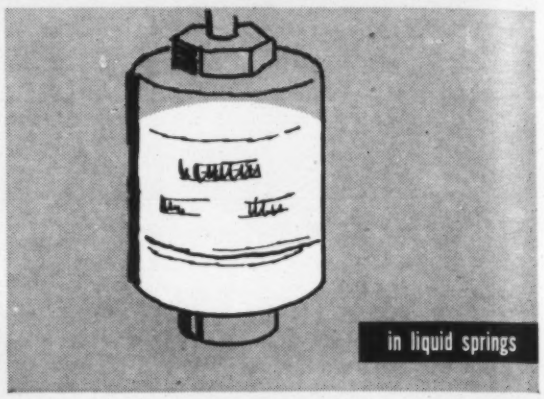
Antifoam B, the lowest priced silicone foam-killer, has greater stability than any other water dilutable silicone defoamer commercially available. Antifoam B will not separate, oil out, settle or precipitate in most applications; retains uniformity and effectiveness even under adverse storage or operating conditions. Ready to use, it requires no diluting or pre-mixing. *No. 464*

"More Muscles for Tomorrow"—A movie in color and sound, gives visual proof of the benefits of silicone electrical insulation. Silicone insulation means increased production, reduced maintenance, freedom from over-motoring, and savings in space and weight. A folder describing the movie and explaining how to arrange for showings is yours on request. *No. 465*


in torsional vibration dampers


in damping delicate instruments

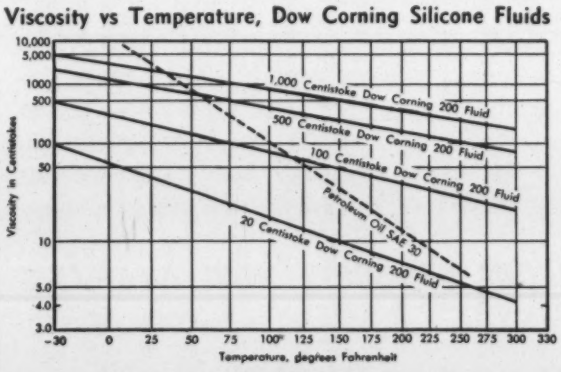

in transmitting torque


in liquid springs

Silicone Fluids Make Automotive Components Perform More Reliably, More Uniformly

Because Dow Corning silicone fluids retain near-constant viscosity over broad temperature spans, they are helping designers hurdle performance barriers set by the limitations of organic fluids, and thereby open the way to many design improvements.

Viscosity vs Temperature, Dow Corning Silicone Fluids



Frequently specified as damping media, coupling fluids and compressible fluids, silicones have proved successful in such designs as torsional vibration dampers, hydraulic couplings, liquid springs, dashpots, delicate gages and instruments.

Future applications in the automotive, aviation and other fields seem limitless when you consider the unique basic properties of silicone fluids: 530 degrees serviceable temperature range, —130 to 400 F; great resistance to oxidation and viscosity breakdown due to shear; high degree of compressibility; low coefficient of expansion.

Available in many viscosities, Dow Corning silicone fluids assure dependable, uniform service under operating conditions that cause organic oils and fluids to deteriorate rapidly. *No. 458*

ADHESIVES FOR TEFLON *(Cont.)*

insulators, and are little affected by extremes of heat, cold and weather. Several manufacturers are now producing silicone adhesive tapes with special backing materials to suit the needs of specific applications. *No. 459*

Dow Corning Corporation, Dept. 7024, Midland, Michigan

Please send me: 456 457 458 459 460 461 462 463 464 465

NAME _____

TITLE _____

COMPANY _____

STREET _____

CITY _____ ZONE ___ STATE _____

SILICONE NEWS is published for product design and development engineers by

first in silicones

Dow Corning CORPORATION
MIDLAND, MICHIGAN

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CANADA: DOW CORNING SILICONES LTD., TORONTO GREAT BRITAIN: MIDLAND SILICONES LTD., LONDON FRANCE: ST. GOBAIN, PARIS

Why jet engines are harnessed with *Carpenter* Welded Stainless Tubing

Reason One: For measuring their exhaust temperature. They're harnessed with the circular assembly of 1″ O.D. Type 430 Carpenter Tubing shown above. Inside it are two wire loops connected to thermocouples on the engine tail-cone. Made in diameters of 12″ to 36″, this harness has to withstand up to 1000-degree heat, corrosive fuel and atmosphere, engine shock and vibration.

Reason Two: Type 430 Carpenter Tubing provided *more* than the strong resistance to heat, corrosion and shock, and the low coefficient of expansion required in this punishing service. Being *welded* tubing, its uniform walls, working properties and dimensional accuracy to 0.003″ throughout were important production advantages for the "harness-maker". Precise bending, flaring and other fabricating operations were accomplished trouble-free.

Next time you need stainless tubing for pressure, corrosion resistance, mechanical, structural or sanitary requirements, call in your nearby Carpenter Representative or Distributor. Have him tell and show you why the quality and uniformity of the welded tubing he sells saves time, trouble and money. Meantime, send for Selecting and Buying Guide, Bulletin T.D. 120.

You are sure of getting all these tubing advantages from Carpenter:

• Uniform wall thickness throughout the length of the tube • Smooth surfaces, I.D. & O.D. • Uniform analysis • Guaranteed 100% pressure tight • Maximum workability • Full corrosion resistance throughout • Heat exchanger quality • Widest range of analyses • Lower initial cost.

The Carpenter Steel Company, Alloy Tube Division, Union, N. J.

Export Dept.: The Carpenter Steel Co., Port Washington, N.Y.—"CARSTEELCO"

Carpenter

more than corrosion resistance

Stainless Tubing & Pipe

For more information, turn to Reader Service card, circle No. 381

Pangborn Hydro-Finish cut cleaning time 50% in this plant

Paid for itself in only six months

Pangborn Hydro-Finish really paid off for this leading glass manufacturer. Cleaning quality increased moldlife 10% to 15% and total cleaning and polishing time was cut in half! The resultant savings paid for the machine in six months and represented a substantial weekly sum thereafter.

USE PANGBORN HYDRO-FINISH FOR:

Deburring • Surface finishing • Finishing threaded sections • Improving cutting tool life • Maintaining dies and molds • Removing grinding lines • Removing heat treat scale • Preparing surfaces

Today, through new design and use of air jet sluriators, Pangborn Hydro-Finish costs less originally, costs less to maintain and gives you easier handling and added efficiency. Write for Bulletin 1403 to PANGBORN CORP., 1700 Pangborn Blvd., Hagerstown, Md.

Manufacturers of Blast Cleaning & Dust Control Equipment

Pangborn

BLAST CLEANS CHEAPER

Why NEW Parker floats are better than cork or metal

Better than cork. Lighter than cork . . . can be used in higher temperatures. Need no protective coat, yet are resistant to fungus and won't waterlog, thus maintaining stable weight and volume.

Better than metal. Can't rust or corrode . . . won't fail from punctures or vibrations.

Can be machined or drilled to your specifications.

Where can you use them? In all types of aviation and jet fuels, oil, water, many other liquids. Molded to your particular needs. Send for catalogs No. 5810 and No. 5870.

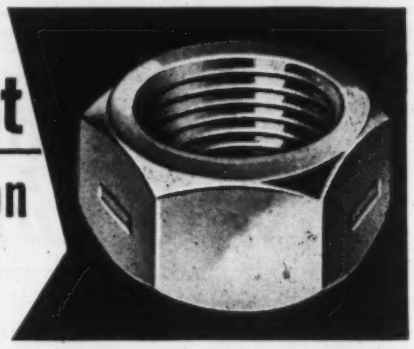
Developed by makers of widely used Parker O-rings.

Parker Hannifin

creative leader in fluid systems

Parker Rubber Division, Section 529-W, Parker-Hannifin Corp., 1538 South Eastern Ave., Los Angeles 22, Cal., or 17325 Euclid Avenue, Cleveland 12, Ohio.

NEW Centerlock Nut saves production time... speeds application



Here is a new low cost lock nut that can be applied from either end, double chamfered, with the locking feature in the center. The greater speed in application of these Centerlock Nuts can make definite savings in production time and provide low cost fastening. Ideal for customer assembled products.

The New Centerlock...

• Can be automatically fed • Will lock wherever turned on bolt • Does not depend on friction against work for locking • Can be applied from either end • Will not damage bolt threads • Available in steel. Brass, aluminum or stainless on special order • Offered in finished series, double chamfered from ¼" thru ⅞" in fine or coarse threads. Machine screw sizes #8, #10, and #12 also available. Heavy series made to special order only • Also in closed and open end acorn type • Large inventories carried for immediate shipment.

119

Write for samples and NEW CATALOG today

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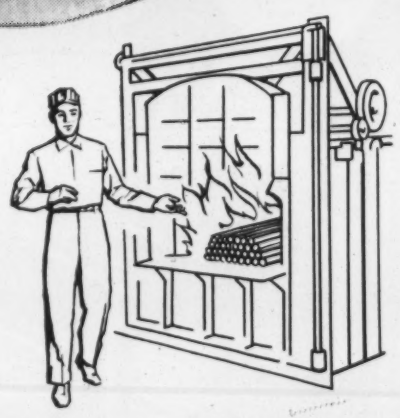
Full annealing is one reason why you get the maximum corrosion resistance in each foot of Standard pipe or tubing.



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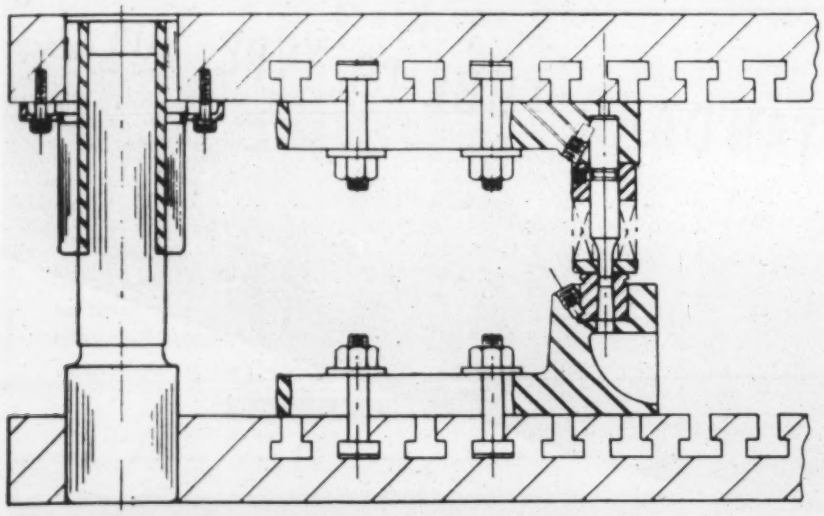
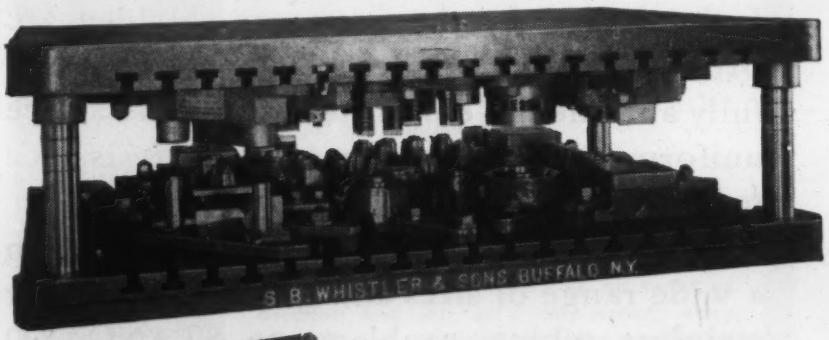
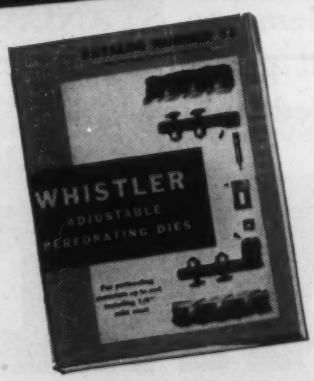


Above: Sectional drawing of a Whistler adjustable punch and die unit assembled in T-slot die set. **Below:** A completely assembled Whistler adjustable die ready for the press.





YOU NEED THIS CATALOG

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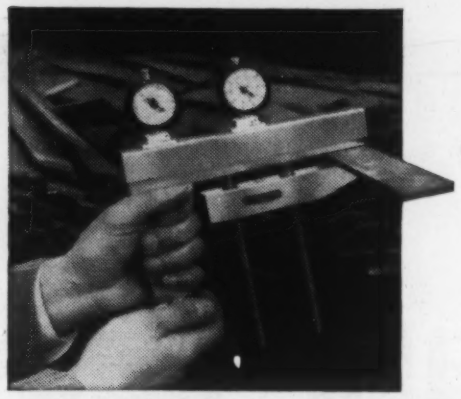

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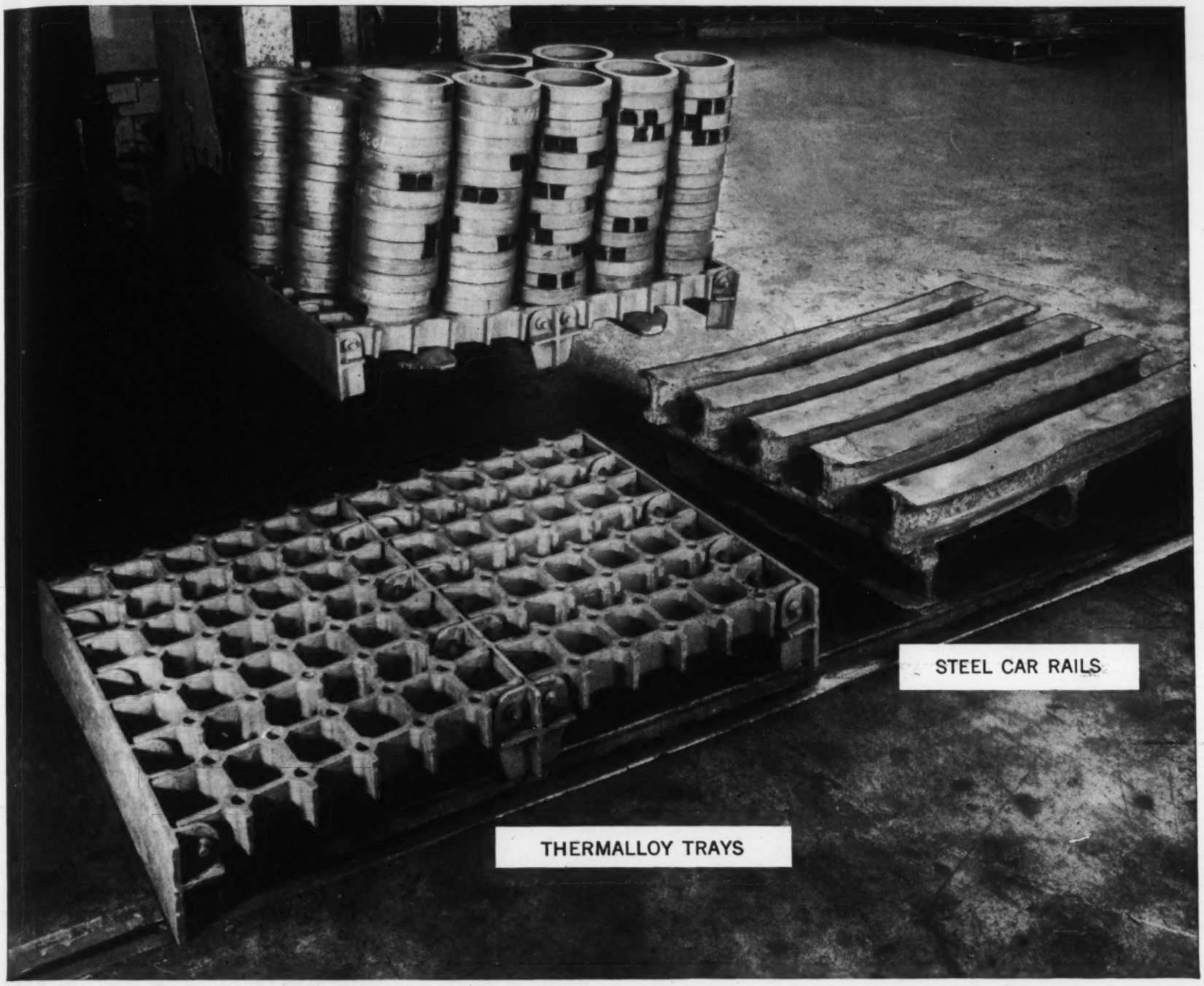

Thermalloy* Heat-Resistant Trays Cut Costs for SKF Industries

At SKF Industries in Philadelphia, steel forgings are annealed in a car-type furnace at temperatures between 1450 and 1650 degrees F. Steel car rails were used to support the forgings in the furnace. But these warped and scaled after short service and became useless.

At the same time, SKF tried the specially designed trays of Thermalloy "30" shown above. These trays have given *six times the service life* obtained from the rails—and are still in use, with many more months of service left. In a cost comparison with the steel rails, SKF found that the Thermalloy trays were less expensive, considering *only* their service life to date.

Thermalloy heat-resistant alloys and Electro-Alloys' design know-how are providing longer service life in scores of heat-treat applications and are saving money for users.

Whatever your heat-treat problem, it pays to contact Electro-Alloys. For further technical information on Thermalloy trays and fixtures, call your nearby Electro-Alloys representative or write for Bulletin T-227. Electro-Alloys Division, 80212 Taylor St., Elyria, Ohio.

*Reg. U. S. Pat. Off.

AMERICAN Brake Shoe COMPANY

ELECTRO-ALLOYS DIVISION Elyria, Ohio

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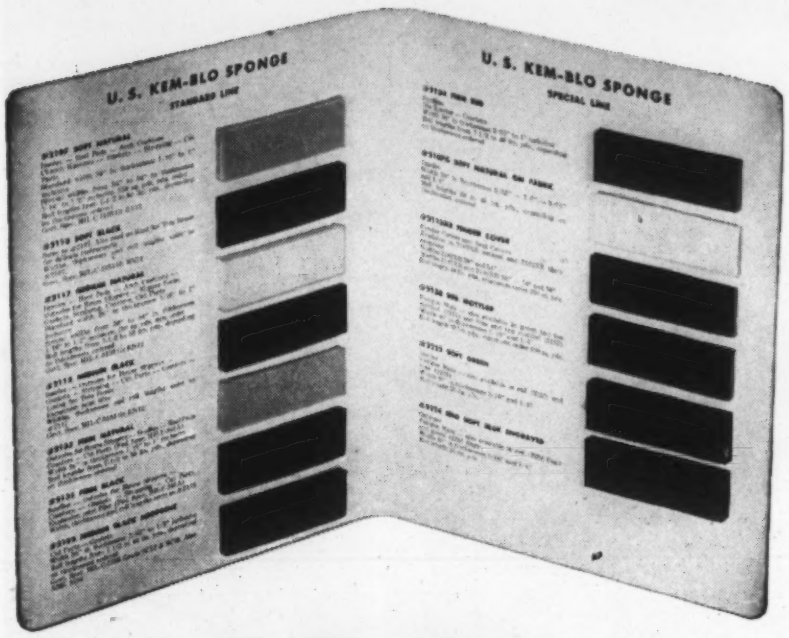

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This 20-page fact-filled STAR catalog contains complete descriptive and engineering data on the full line of STAR Ceramics. A big selection chart, complete with mechanical and electrical properties, makes the job of selecting the right STAR material for your product a cinch. Like a free copy? Write *today* for Catalog 57.

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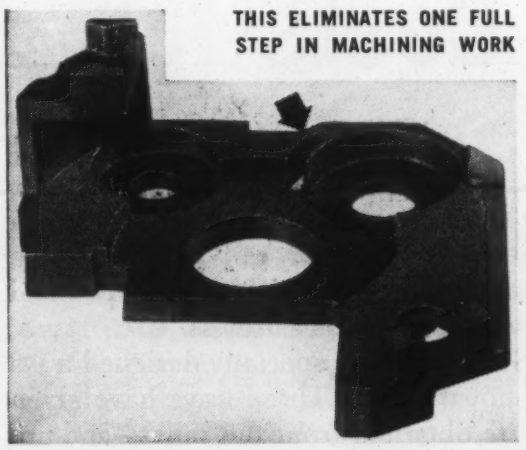
he worries about small parts

he has his made by OPC

THIS ELIMINATES ONE FULL STEP IN MACHINING WORK



Just in case you think small parts can be too complex for OPC plaster mold casting, look at this one, of 356 aluminum, heat-treated to T-6 stage. Every plane, angle and curved surface is held to ±.005 tolerance where requested, and always within tolerances that require but a minimum machining time. Once an experimental project, this casting is now a production item, reordered regularly. Better send for our NEW brochure—you'll find it interesting and helpful.

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First, there are of course the many different weaves, meshes, metals, finishes and coatings that provide for infinite combinations to meet any special requirement right on the nose.

Secondly, and highly important, Reynolds also "tailors" wire cloth to the precise *width* and *length* needed to minimize waste and to shave the last bit of excess cost out of production operations.

Finally, Reynolds helps you take the fullest advantage of these variables by providing truly unmatched engineering and analytical service . . . nation-wide. Can wire cloth do a *better* job for you? Can you cut costs? Could wire cloth be the answer for certain *new* requirements? Check with Reynolds . . . see what *Reynolds* service and quality control offers!

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WAGNER LITHO MACHINERY, Secaucus, N. J.; *metal decorating equipment* • **ATHENIA STEEL**, Clifton, N. J.; *flat, high carbon spring steels* • **REYNOLDS WIRE**, Dixon, Ill.; *industrial wire cloth*

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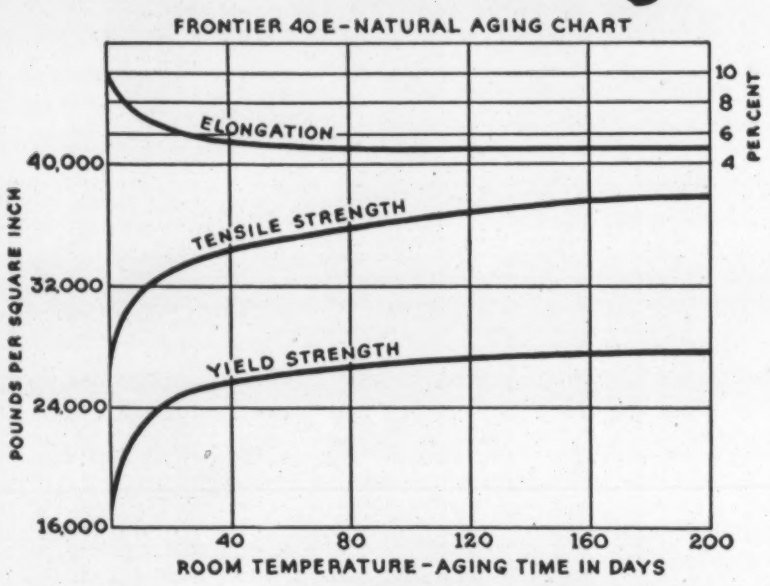

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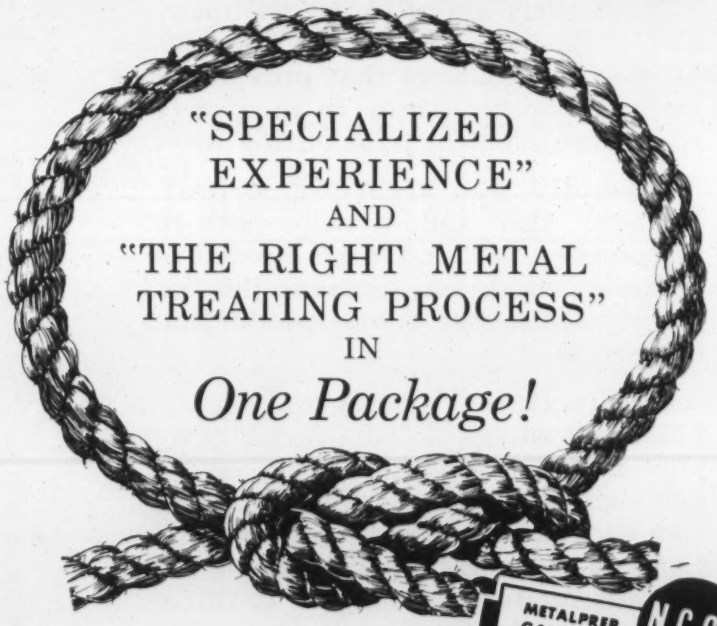

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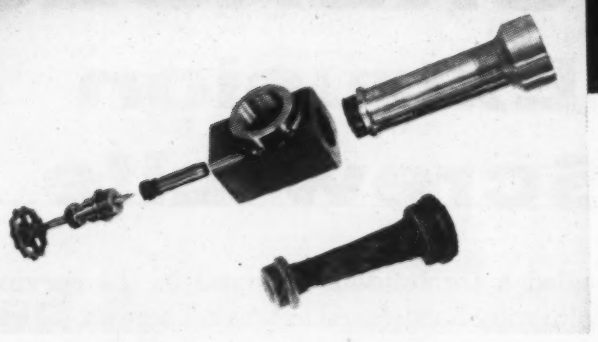
TYPICAL CORROSION RESISTANCES OF ZIRCONIUM AND TITANIUM

CORROSIVE MEDIA	METAL RESISTANCE	
	ZIRCONIUM	TITANIUM
Sulfuric Acid	excellent to good below 80%	good below 5%
Nitric Acid	excellent	excellent
Hydrochloric Acid	excellent	good below 10%
Phosphoric Acid	excellent to fair below 85%	poor
Chromic Acid	excellent	excellent to good
Aqua Regia	poor	excellent
Wet Chlorine Gas	poor	excellent
Chlorine Water	excellent	excellent
Sodium Hydroxide	good below 90%	good below 50%
Ferric Chloride	poor	excellent
Calcium Chloride	excellent	excellent
Cupric Chloride	poor	excellent
Sodium Chloride	excellent	excellent
Ammonium Chloride	excellent	excellent
Aluminum Chloride	excellent	excellent to fair

Corrosion resistances of zirconium and titanium to typical chemicals are shown above.



At right is a steam jet made of zirconium which has given trouble-free performance after a year in hydrochloric acid service. For comparison, a throat piece from a steam jet made of cast iron is shown after only a week of similar service.

ZIRCONIUM AND TITANIUM LICK TOUGHEST EQUIPMENT CORROSION PROBLEMS

The use of zirconium, titanium, or alloys of these metals now makes it possible to fabricate equipment that is corrosion-resistant to almost every substance encountered in industry. Even with such difficult-to-handle chemicals as chlorides and oxidizing acids, equipment can have extremely long service life. Problems of product contamination in chemical and food processing can be virtually eliminated.

Costs are cut in two ways. Direct maintenance costs are lowered, but even more important, costly downtime for the replacement of equipment can be avoided. These savings can more than compensate for the relatively high initial investment.

At the moment, equipment can be fabricated from titanium for about twice the price of stainless steel with even lower costs anticipated in the near future. When volume production is reached, commercial grade zirconium will probably cost only 50 to 75% more than stainless steel.

Wider application of these metals at reasonable cost is made possible by increased production and improved techniques provided by new U.S.I. facilities. By the end of this year, U.S.I.'s new titanium plant will add 5,000 tons to the nation's annual output. The new U.S.I. zirconium plant at Ashtabula, Ohio, employing a sodium-reduction process, will be able to supply 1,000,000 pounds of zirconium platelets to industry in 1958, in addition to meeting Atomic Energy Commission commitments.

If you have a corrosion problem, it will pay you to investigate the advantages of using these new metals. For more information, write to Bill Greenleaf, Manager of Metals Development.

U.S.I. INDUSTRIAL CHEMICALS CO.
Division of National Distillers and Chemical Corp.
99 Park Ave., New York 16, N. Y.
Branches in principal cities

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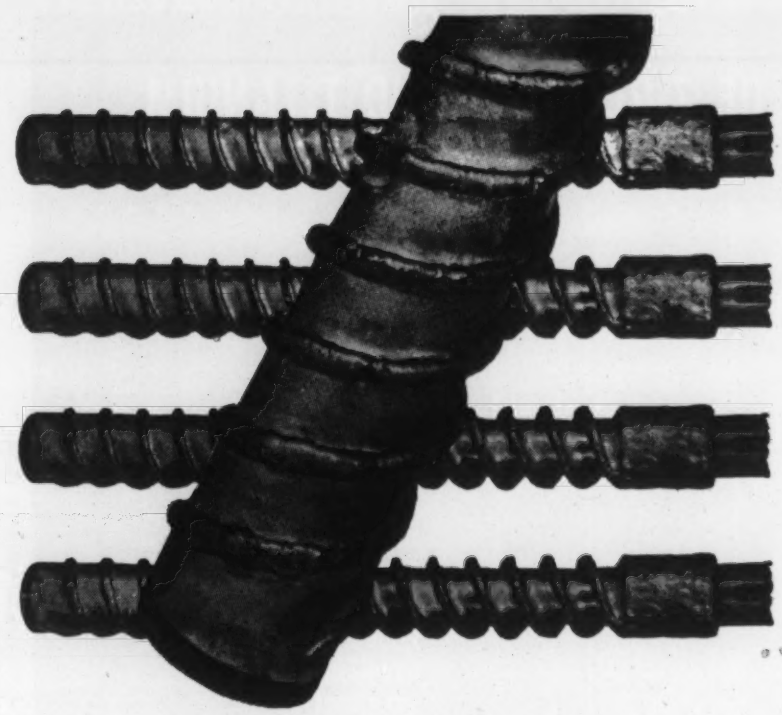
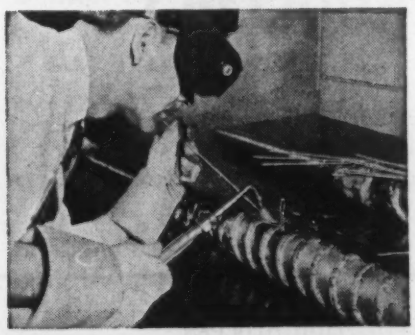


Colmonoy INCREASES Extrusion Screw Life

Tests revealed a tremendous increase in the service life of these Colmonoy hard-faced extrusion screws, as against the unprotected screws usually used. Orders for new replacements now specify Colmonoy hard-facing.

Used for extruding plastic, these screws are made of age-hardening nickel-base alloy. This alloy is now readily hard-faced with little loss of hardness, using Colmonoy No. 6 gas rod and a new Colmonoy high temperature flux.



The 60-inch screws have a .050" overlay of Colmonoy No. 6 when finish ground. Colmonoy hard-facing pays for itself in increased life very quickly on expensive parts such as these.

To provide any metal part with longer life, investigate Colmonoy alloys and methods. They represent a complete line of wear resistant alloys and the most up-to-date in hard-facing techniques.

Submit part drawings and a description of the wear encountered for a specific recommendation. Request Hard-Facing Manual No. 79.

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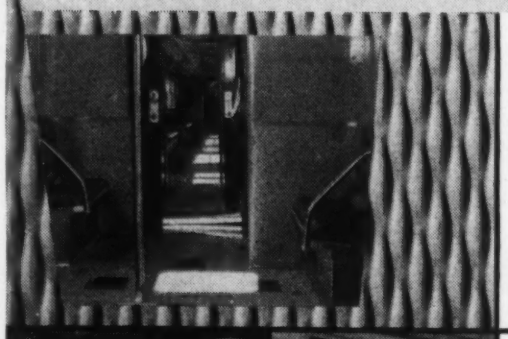
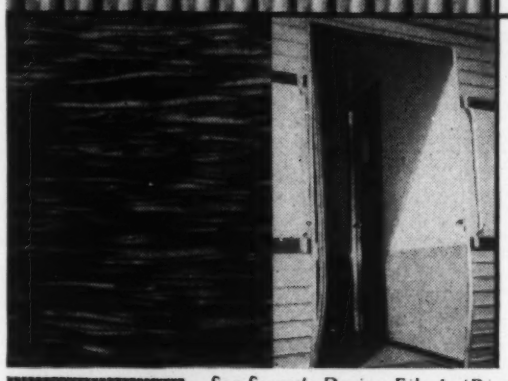
RIGID-tex METAL

demonstrates its Superiority ON THE RAILS



Wherever the going is rough, you'll find RIGID-tex Metal. Wainscoting and seat bases in this subway car are stainless RIGID-tex Metal pattern 5-WL.



Newest in rail transportation, the TALGO uses Stainless RIGID-tex Metal (Pattern 1-CS painted and hi-lited) for wainscoting. Takes kicks and scrapes yet remains new looking always.

See Sweet's Design File 1a/Ri or write for more information.

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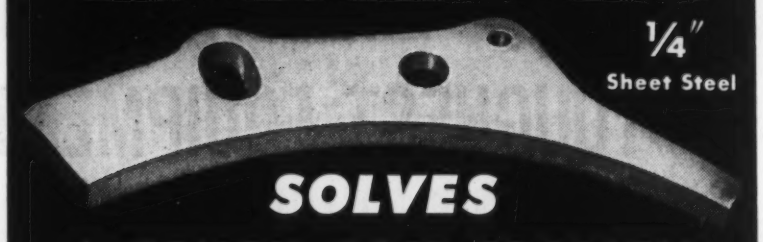

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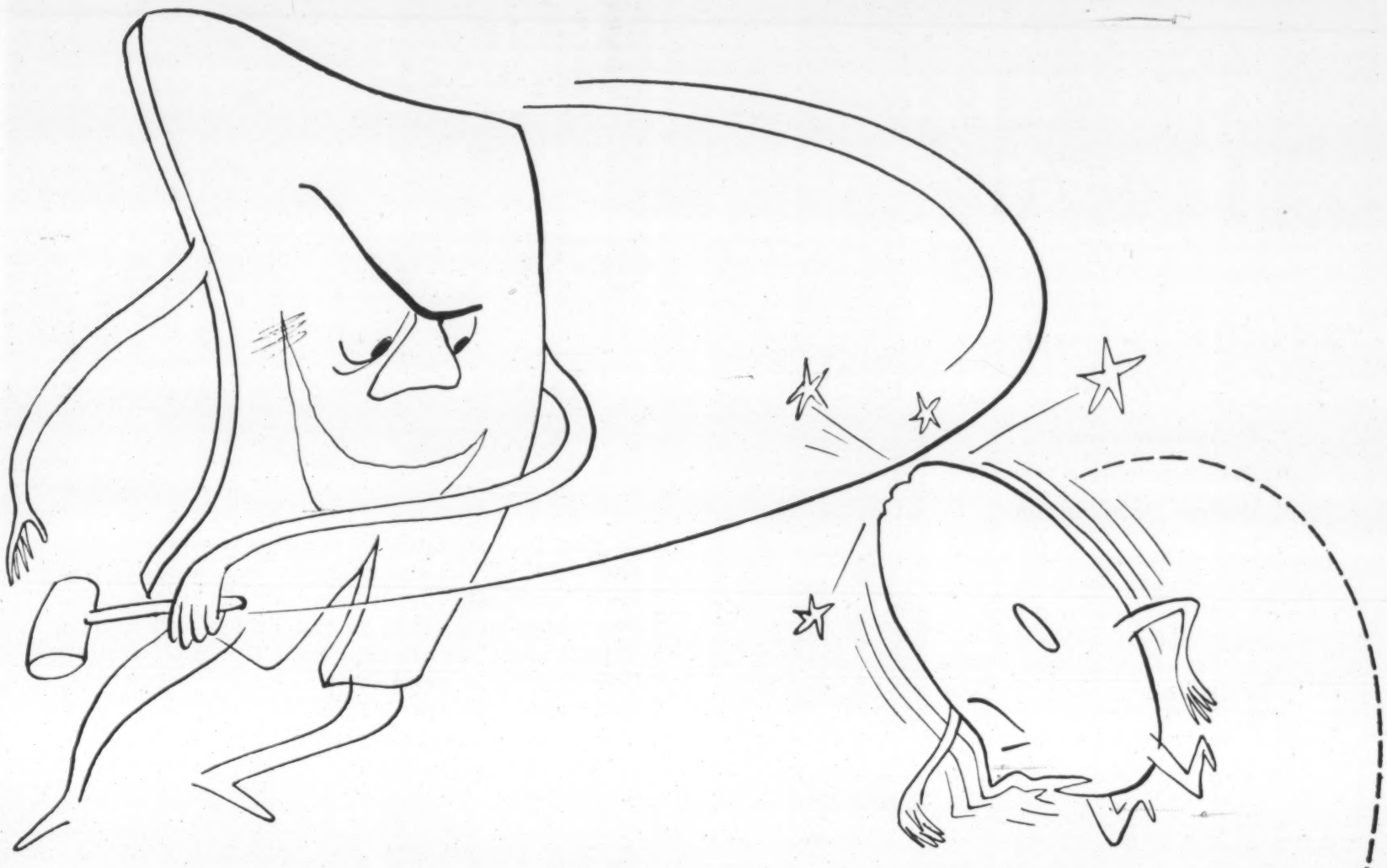
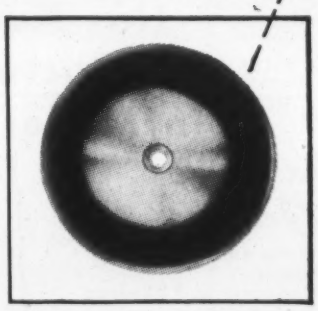


No matter how they sliced it, RUBBER dulled their SKIVING KNIVES

The skiving knives used by a rubber processor had a short service life because rubber is highly abrasive. The disk-shaped blades had to be re-sharpened after each working shift, resulting in costly down time.

By Flame-Plating the knives on one side with tungsten carbide, their service life was increased 15-fold. Also, the knives gained the advantage of a self-sharpening effect: as the uncoated steel side wears more rapidly than the coated side, a sharp edge is always presented to the material being cut.

Flame-Plating is LINDE's special process for coating metals with a very hard and durable surface. By this method, tiny particles of tungsten carbide or aluminum oxide are literally *blasted* onto almost any metal surface. Most important, the temperature of the part seldom exceeds 400-degrees F., so there is little or no chance of changes in the shape or metallurgical properties of the part being coated. Flame-Plated coatings can be applied from .010 to .002 inches thick, and finished to 0.5 microinches rms.



The machinery and equipment you use to fabricate rubber can have its service life greatly extended at critical points of wear by Flame-Plating. For more information, write for a free copy of the booklet, "Flame-Plating," F8065. Address Flame-Plating Dept., LINDE COMPANY, Division of Union Carbide Corporation, 30 East 42nd Street, New York 17, N. Y. Offices in other principal cities. *In Canada:* Linde Company, Division of Union Carbide Canada Limited.

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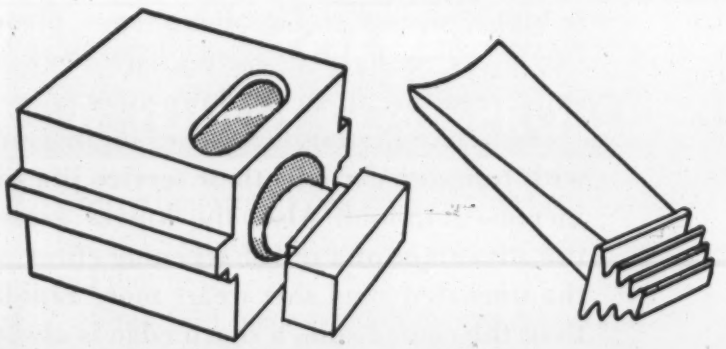

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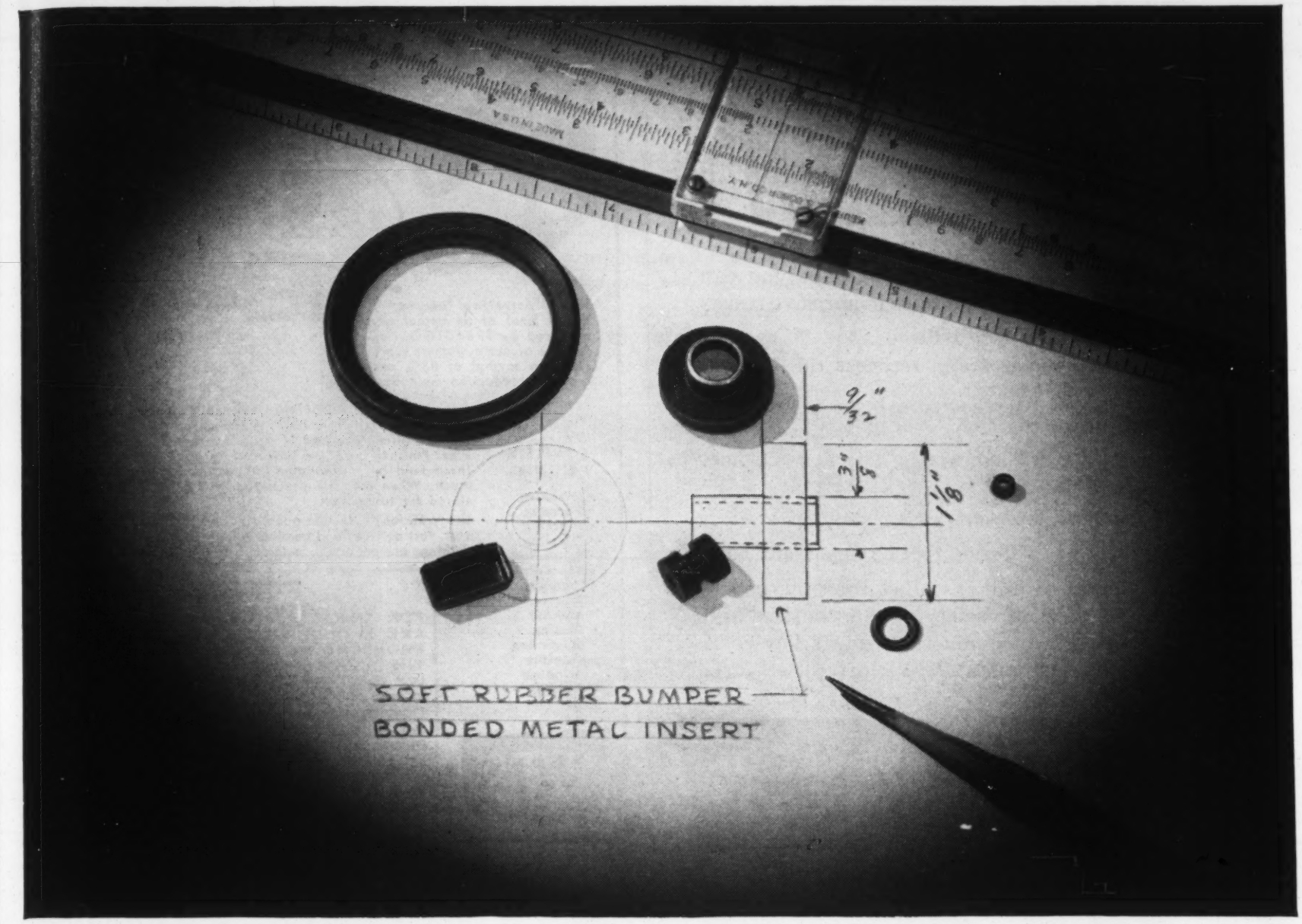

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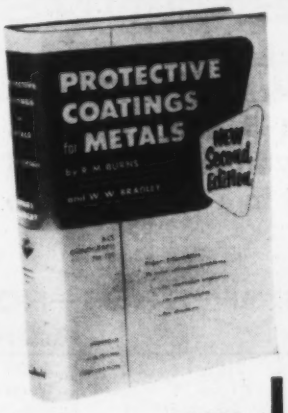

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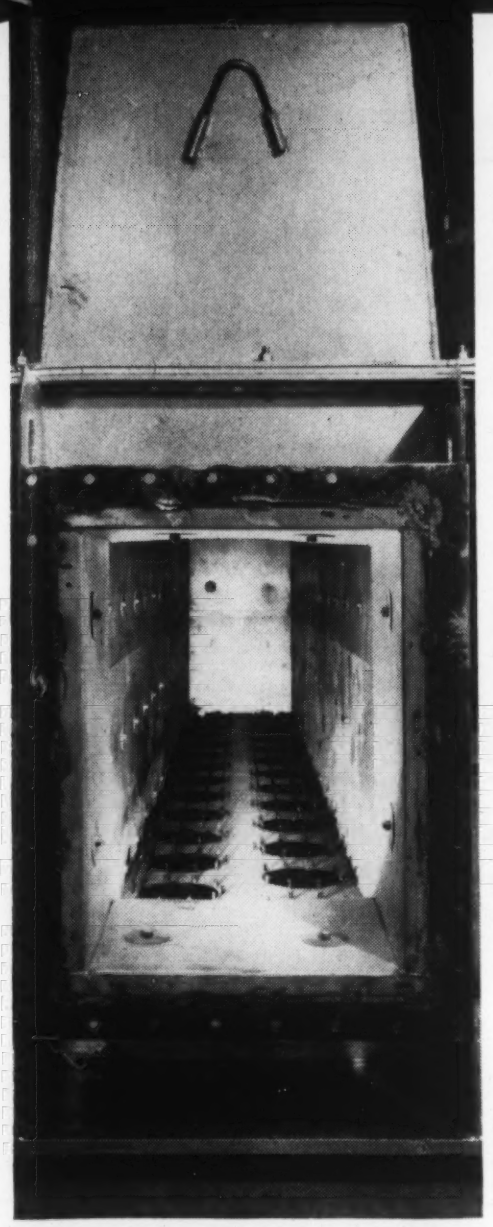
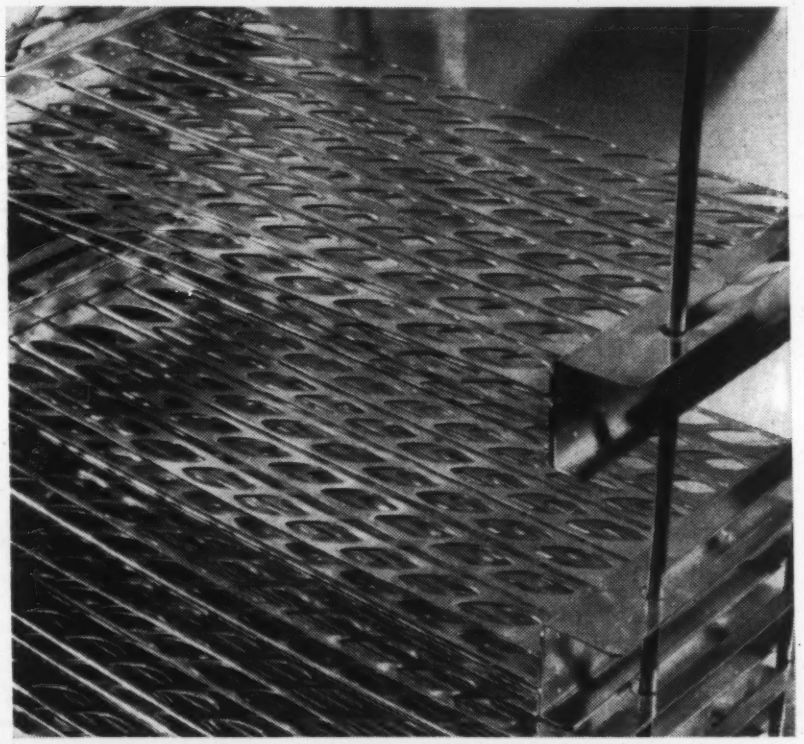


For High Temperatures. This recuperator is used on industrial furnaces. It uses waste flue gas to heat the incoming furnace air and thereby increase the efficiency of the furnace. Formerly, these recuperators were made with ceramic tubes, but heat transfer was low and leakage was high. The Hazen Engineering Company in Pittsburgh makes recuperators almost completely from Stainless Steel. Compared to ceramic designs, the Stainless design saves about 40% in fuel, increases furnace output about 10%-15%. The Stainless Steel performs well, even at this 1800-2300° F. temperature range.



For Cleanliness. When you work near nuclear radiation areas, you wear a small badge containing X-ray film that records how much radiation you have received. The film, "photodosimetric film," is developed in a Sensitometric Processing Unit made by Bar-Ray Products, Inc., in Brooklyn. The unit, including the trays shown here, is made completely from 18-gage Type 316 Stainless Steel because it resists corrosion, is easy to clean, has a hard, dense surface that doesn't harbor dirt.

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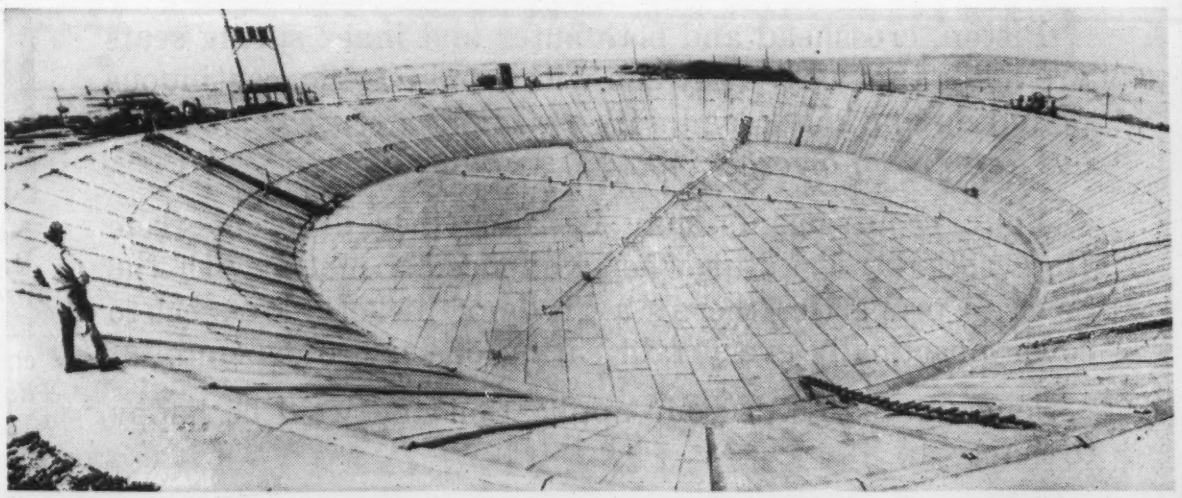
For Corrosion Resistance. The Hercules Powder Company needed an ammonium nitrate storage tank for their plant near Richmond, California. They took an old World War I concrete reservoir and lined it with Type 304 USS Stainless Steel. The 14-gage sheets are laced with 18,000 feet of vacuum-tested welds. Tank holds two **million** gallons of solution, and is 200 feet in diameter at the top. U. S. Steel's Consolidated Western Division handled the complete installation.



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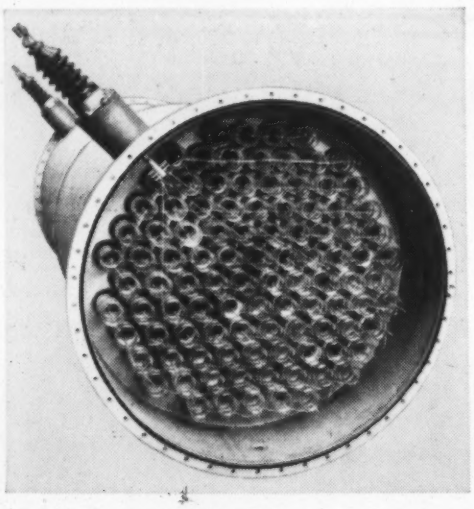
The ozonator is a steel shell packed with glass tubes. As dry oxygen passes through the tubes, it is converted to ozone by high-voltage electrical discharge. Each end of the shell is closed by a dished head sealed with a gasket of HYPALON.

Plastic gaskets too rigid

Plastic gaskets, which were formerly used in the generators, were unaffected by ozone, but took a permanent set under flange pressure. When a head was removed for routine maintenance the plastic gasket was too distorted to put back. Gaskets of HYPALON are reused.

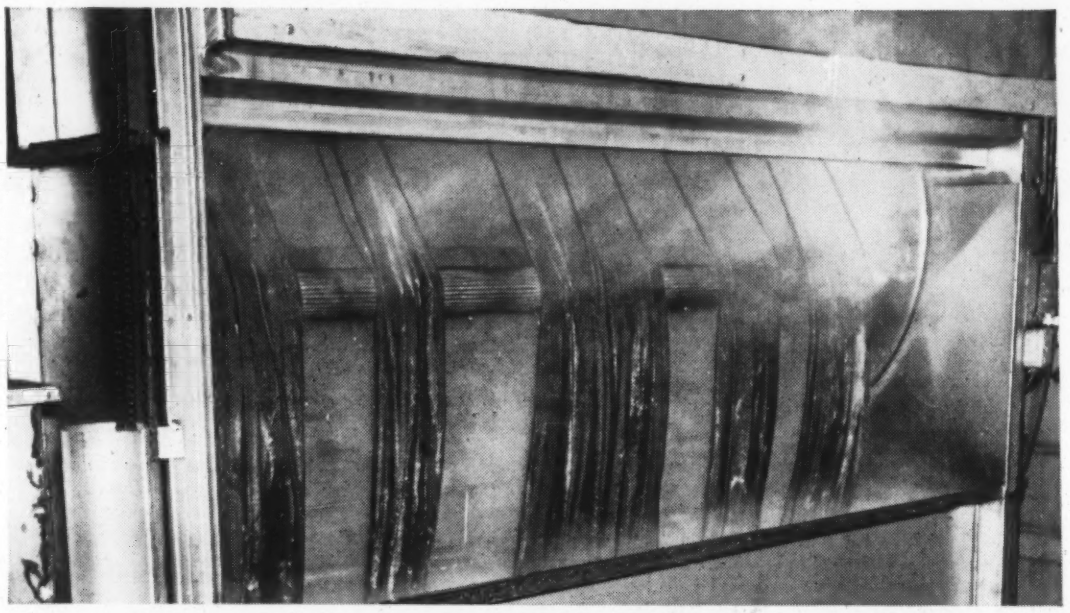
HYPALON offers many additional advantages compared to other types of rubber. It resists strong oxidizing acids; can operate at temperatures from 250° F. to 350° F.; resists weather and sunlight. This Du Pont synthetic rubber can also be compounded in an unlimited range of stable colors. HYPALON offers extra long life and lower operating costs in jobs where conditions are severe. Mail coupon for full information.



Gaskets made of HYPALON seal each end of this ozonator; they show no deterioration after two years in service.

HYPALON *is a registered trademark of E. I. du Pont de Nemours & Co. (Inc.)*

"Non-skid" neoprene reels help dye slippery synthetic fabrics



Fluted neoprene bars show little wear after four years in dye machine. Dye bath may be acid or alkaline, oxidizing or reducing. Temperature is 200° F.

Mill uses neoprene to get needed traction for hauling fabric through dye bath

Chatham Manufacturing Co., of Elkin, N. C., used neoprene to solve an unusual problem in dyeing synthetic fibers. Long loops of the fabrics are dyed in stainless steel piece dyeing machines. Loops, often 100′ long, are pulled through the dye bath by means of a reel. The slow rotation of the reel assures even dyeing over the full length of the goods.

The progress of the fabric depends entirely on friction between reel and loop. When several types of metal reels failed to produce enough friction to pull the smooth synthetic fabrics through the bath, Chatham designed special fluted neoprene bars for the reels. They provided adequate traction and ended the problem of slippage and uneven dyeing.

Chemical resistance important

Bars covered with natural rubber could have solved the traction problem but neoprene was chosen for its excellent chemical resistance. In dyeing various fabrics the dye bath may be acid or alkaline, oxidizing or reducing. Each dyeing cycle requires 3-5 hours at 200° F., and the dye machines operate 24 hours a day. Ordinary rubber just couldn't stand this treatment. Chatham's Superintendent of Dyeing, Mr. V. Caton, reports that neoprene has given excellent service for four years with little wear.

Neoprene's resistance to chemicals, heat and abrasion means long-term wear—and economy in many types of service. Mail coupon below for full details on how neoprene can work for you.

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We assure complete uniformity by taking extra quality control steps. For example, we were the first steel manufacturer in the U.S. to use a magnetic stirrer for molten steel. It distributes alloys equally, keeps temperature uniform, and works the slag continuously.

To assure still further uniformity, your order is handled individually. Conditioning procedures are targeted to meet your end use requirement. To limit variations within an order—as well as from order to order—we stamp each bar to identify its heat.

To increase the availability of your automatic forging equipment —at no extra cost—always specify Timken fine alloy steel. You'll get money-saving performance and uniform results every time. The Timken Roller Bearing Company, Steel and Tube Division, Canton 6, Ohio. Cable address: "TIMROSCO".

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